

Paleomagnetic Study of Scanian Dolerites and Basalts

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ABSTRACT

For paleomagnetic studies oriented samples have been collected from quartz dolerites, melaphyres, and basalts in Scania, southern Sweden.

The study revealed in the quartz dolerites a stable characteristic magnetism, which gave a virtual geomagnetic pole position at 39°N , 172°E . The melaphyres presented varying degree of magnetic stability due to secondary mineralogical alterations. Magnetic directions were isolated and the various types of melaphyres gave magnetic pole positions at 57.5°N 165°W , 22.5°N 162°E , and 52°N 167°E . The paleomagnetic data from the quartz dolerites and the melaphyres indicate an Upper Carboniferous - Lower Permian age for those rocks.

The basalt samples contained stable magnetic components of both normal and reversed polarity. The calculated mean magnetic pole is situated at 57.5°N 101°E . Previous K/Ar determinations placed the basalts in the middle to upper Mesozoic. The basaltic pole position coincides with some of the published Jurassic paleomagnetic poles for Europe.

INTRODUCTION

This paper presents the results from a study of the natural remanent magnetism (NRM) in quartz dolerites, melaphyres, and basalts in Scania, Southern Sweden. In all 290 samples from 40 sites have been measured.

The work commenced in 1968 on the initiative of Prof. Sven Hjelmqvist and with a grant from the Swedish Natural Science Research Council. After construction of necessary measuring instruments, sampling started in 1969. The aim of the research was to study the magnetic properties of the Post-Silurian igneous rocks in Scania. Some of the Scanian quartz dolerites have already been studied paleomagnetically (Mulder, 1971), and they belong to a period, the Upper Paleozoic, for which European paleomagnetic data are well defined. It was of interest to study the relation of those rocks to the melaphyres in Scania and to try to find, through magnetic methods, if they are contemporary. The basalts have recently, through radiometric dating (Prinzlau and Larsen, 1972), been placed in the Mesozoic, and as European paleomagnetic data from that era, especially the Jurassic and the Cretaceous, are scarce, it was considered valuable to investigate their magnetic directions.

PALEOMAGNETIC CONCEPTS

The Earth's magnetic field approximates that of a dipole and averaged over several thousands of years, the dipole axis coincides with the Earth's rotation axis (Irving, 1964 p. 2). That this assumption is valid for geological time has been made evident by Benkova et al. (1973), who with the use of analytical models of the paleomagnetic field, have demonstrated that for the past 300 m.y. the geomagnetic field has remained similar to that of a dipole slightly shifted from the Earth's centre.

When igneous rocks, that contain some magnetic mineral, for example magnetite, cool in the Earth's magnetic field from a melt and the temperature passes the Curie temperature for the magnetic mineral the rock acquires a magnetic moment directed parallel to the existing geomagnetic field at the time of cooling. That magnetism, TRM or thermoremanent magnetism, is considered stable and does not change if the geomagnetic field changes in direction and intensity. This means that if oriented samples are collected from a rock magnetized in that manner and the direction and intensity of their magnetic moment are measured, a picture of the Earth's magnetic field at the time of the rock's formation is created. Sedimentary rocks can acquire such 'fossil magnetism' by alignment of magnetic particles, so that they are parallel with the ambient geomagnetic field during deposition. This sedimentary remanence is called depositional remanent magnetization (DRM). Rocks can also obtain a magnetic remanence at temperatures below the Curie temperature by formation of magnetic minerals through oxidation or other chemical processes. This is called chemical remanent magnetism (CRM).

Through the study of magnetic directions in rocks from different periods it has been found that the Earth's magnetic field more or less frequently has changed polarity. According to convention the direction is called normal when it has the same polarity as the present field, otherwise the direction is termed reversed.

Secular variation is the fluctuations of the magnetic field in about 10° to 20° around the average field direction. It occurs with periodicities of hundreds to thousands of years. In a rock formation which has been formed or cooled during times longer than that, for example, a wide sequence of sedimentary rocks or a thick dyke or igneous body, this effect would be averaged if properly sampled. In thin sheets of rock it would be noticeable and cause deviations in direction.

The study of fossil magnetism or paleomagnetism did much in the last decenniums to revive the theories of continental drift. It was found that when paleomagnetic poles calculated from rocks of a certain time period on one continent were compared with the paleomagnetic poles from rocks of similar age on other continents, the pole positions did not always coincide. Reasons for that difference could be an apparent movement of the pole in relation to one of the continents, apparent polar-wander, or the continents could have moved in relation to each other. This, together with the studies of magnetic anomalies across mid-oceanic ridges, has laid the foundation for the 'new geology' with the concepts of sea-floor spreading and plate-tectonics.

Apart from the determination of continental drift, paleomagnetic data can also be used within smaller areas for estimating tectonic movements between different geological blocks of similar age. By comparing magnetic directions from different rock units and through apparent polar-wander curves there are possibilities to date separate formations. In this way paleomagnetism can supplement radiometric dating. A geomagnetic time scale based on changes in polarity of the geomagnetic field has been constructed, which goes back to the Cretaceous (Heirtzler et al., 1968). This pattern of reversals can also be used for dating.

GENERAL OUTLINE OF SCANIAN GEOLOGY

Scania, which is the southernmost part of Sweden (map fig 1), is situated on the border between the Precambrian Fennoscandian Shield and the North European sedimentary basin.

The basement rocks consist of gneisses and gneiss-granites of both sedimentary and igneous origin (Törnebohm and Henig, 1904, Hjelmqvist, 1934). They belong to the southwest Swedish gneiss area which stretches from Scania through southwestern Sweden to northern Värmland. These gneisses are

probably older than the Svecofennian rocks in central Sweden which are K/Ar dated to 2100-1680 m.y. (Magnusson, 1963). Intrusive in the basement is a set of dolerite dykes which trend N-NE. In Scania, south of an approximative line from Simrishamn in SE to Ängelholm in NW, the Precambrian basement disappears below younger sedimentary rocks and outcrops south of that line only in isolated but topographically dominant ridges, of which the horst Romeleåsen, E of Lund is the largest.

In the late Precambrian the Scanian basement rocks were exposed to weathering and erosion and were peneplained. With a transgression in the early Cambrian Scania became part of the European sedimentary basin. The lower Paleozoic sedimentary rocks in Scania are summarized by Regnell (1960) and Thorslund (1962). In short the lower Paleozoic litho-stratigraphy is:

Cambrian arkoses, quartzitic sandstone, and shales,
Ordovician limestones and shales,
Silurian limestones, shales, and sandstones.

Sedimentary rocks of Devonian, Carboniferous, and Permian age are not found in Scania, so they are either completely eroded or Scania was above sea-level during those periods.

Mesozoic sediments from the Lower and Middle Triassic have been found in boreholes. The oldest known outcrops are from Upper Triassic (Keuper). The Mesozoic of Scania has been summarized by Brotzen (1960, 62). The litho-stratigraphy is:

Triassic sandstones and conglomerates,
Jurassic claystones and sandstones,
Cretaceous claystones and limestones.

Cainozoic sediments, conglomerates, sand, and clay are found in some small areas at Malmö, Ystad, and south of Kristianstad.

Scania is crossed by a set of faults with main directions in NW-SE and NNE-SSW. The former direction prevails (Nathorst, 1887). This has created a system of more or less elevated blocks which has helped to preserve the different sedimentary rocks and is responsible for the mosaic pattern of the bedrock in Scania.

Behrens (1953) has summarized the theories which deal with the Scanian dislocations and their age. The general idea is that the fault lines have been activated repeatedly, mainly in connection with mountain building processes in central and southern Europe. Hjelmqvist (1939), connects the NW-SE faults and accompanying dyke systems with dykes along the Swedish west coast and with the tectonic movements and volcanism in the Oslo area. This implies that they are of Lower Permian age and that the dislocations which created the flexure along the SW border of Fennoscandia are of the same age and are connected with the Variscan movements in Europe.

Böslau (1959, 72), who has especially studied the Mesozoic rocks in NW Scania, regards the post-Variscan tectonic movements as tensional and connected with Saxonian block movements in Northern Europe. The area with basalt occurrence N and NW of the lakes Ringsjöarna is submerged between the horsts Söderåsen, Hallandsåsen, Nävlingeåsen, and Linderödsåsen, and the volcanism in this area is probably connected with some of the dislocations that formed the horsts.

The post-Silurian tectonics in Scania are dominated by movements along vertical or near vertical fault lines, folding is of a minor degree.

DESCRIPTION OF SAMPLED ROCK TYPES

Quartz dolerites

This group of dolerites is called 'Kongadiabases' by Törnebohm (1876) with type locality Konga Klint. As a group

they are further described in monographies and in the descriptions that accompany the different geological map sheets of Scania, published by the Swedish Geological Survey.

The dolerites follow the general NW-SE fault trend and have generally vertical or near vertical dip. Their width varies from a few dm to more than 100 m. Occasionally it is possible to follow them in the terrain for a few kilometres, especially in sedimentary areas, where they appear as ridges.

The dolerites is dark grey to black, hyaline to aphanitic at contacts and phaneritic towards the centre. Contacts with the gneisses are sharp with no visible alteration in the country rock, while shales in contacts are baked, hornfelsed and sometimes brecciated.

Mineral content is plagioclase (basic labradorite), pyroxene (augite), micropegmatite, quartz, and apatite. Opaques are titanomagnetite, ilmenite and sometimes sulphides, mainly pyrite. Often the rock is altered and as secondary minerals there are hornblende, chlorite, serpentine, and calcite, the latter often in amygdaloids. In a few dykes olivine occur in minor amounts and consequently there is little or no quartz.

Below follows a description of sampled localities from SE to NW. Letters in brackets refer to map in fig. 1, and figures refer to the coordinate system, UTM, used in topographic maps of Sweden in scale 1:50,000, published by the Geographical Survey Office of Sweden.

Simrislund (SL), VB 556556: This dyke is situated 2 km S Simrishamn, on the shoreline. It is described by Holst (1892). It is 40 m wide and strikes N 30°W. Country rock is quartzitic sandstone of Lower Cambrian age (Hardeberga sandstone). The feldspar in this dyke is altered and covered by a fine red dust, probably hematite, which gives the rock a reddish appearance. Due to its more exposed situation by

the seaside the rock is rather more weathered than the other quartz dolerites. Samples were collected in a line across the dyke.

Bollerup (B0), VB 409501: This dyke is exposed in a road-cut 1 km E Bollerup, 20 km NE Ystad. It is described by Holst (1892). It is 25 m wide and strikes N 37°W. It is the only dyke sampled that contains some olivine. Samples were collected across the dyke along the road-cut. Country rock is Silurian shale.

Tomelilla-Ullstorp (TU), VB 346539: This dyke is exposed along the road Övraby-Tomelilla, 15 km NNE Ystad. It is described by Johansson (1920). The dyke is 40 m wide and strikes N 30°W. Country rock is Silurian shale. The dyke was sampled in a road-cut and in an abandoned quarry 200 m south of the road-cut.

Dalby (DA), UB 922702: Two dykes in a quarry at Dalby, 15 km E Lund were sampled. The sampling and measuring of the samples was done by Claesson (1971). The quarry is situated on the northwestern slope of the horst Romeleåsen and the bedrock consists of Precambrian gneisses and granites. The rock units in the area have been described by Hjelmqvist (1930, 31, 34). Two parallel dykes were sampled, the distance between them is 100 m. In one dyke, samples were collected at three sites, with one site on another bench level. The bench height is 16 m. The other dyke was sampled at one site. The first mentioned dyke is called DA1, the other DA2.

Hardeberga (HA), UB 928747: This dyke was sampled in a sandstone quarry at Hardeberga, 7 km E Lund. The sandstone is the Lower Cambrian quartzitic sandstone for which Hardeberga is the type locality. The samples were taken and measured by Ejder (1971). Previously Mulder (1971) has collected samples from the same dyke and measured their NRM. The dyke is described by Winkler and Weitz (1956). It is 20 m wide and strikes N 68°W. It traverses the quarry and samples were taken from

both quarry walls some 150 m apart.

Röstånga mölla (RM), UC 936063: This dyke is situated 1 km S Röstånga, 32 km ENE Landskrona. It is described by Hadding (1922). The samples were taken and measured by Sandecki (1973). The dyke is 8 m wide and strikes N 30°W. At the sampling site it is cut by a creek and samples were collected in dyke walls on each side of the creek 100 m apart. Country rock is Silurian shale.

Rönnarp-Tågarp (RT), UC 723023: In a dolerite quarry at Rönnarp 15 km NE Landskrona, samples were collected in the dolerite wall in the northwestern part of the quarry. The samples were taken and measured by Klingspor (1971). Mulder (1971) has previously studied the NRM in the same dyke. It strikes NW and dips 65°SW. There are minor faults in the dyke and the surrounding Silurian shale is brecciated at contacts.

Melaphyres

Under this heading are grouped a set of basic dykes that differ somewhat in composition but are considered to be genetically related. The groups are:

1. The melaphyres of Tolånga type.
2. The melaphyre at Frualid.
3. The basic dykes at Torpa Klint.
4. The kullaite together with the syenite porphyry from Torpa Klint.

1. The melaphyres of Tolånga type

This type of rock is described by Hadding (1916) and Johansson (1920). It outcrops in dykes that vary in width from a few dm to ten m. They are found mainly in the Tolånga area 15 km east of the lake Vombsjön but there are a few occurrences further northwest, south of the lakes Ringsjöarna. Their strike is NW-N and they stand nearly vertical. Country rock is Silurian shale. Contacts are sharp, shales at the contacts are baked and sometimes brecciated and pieces of shale can

be found in the dykes.

When least altered the rock is black, dense to finegrained and similar to basalt. Mineral components are plagioclase (basic labradorite) in two generations, hornblende, apatite, and brownish glass. Opaques are titanomagnetite and some pyrite. The rock is commonly altered and serpentine and chlorite are found as altering products in pseudomorphs after olivine. In the groundmass occurs chlorite and calcite. Amygdaloids are common. They are generally filled with calcite and chalcedony. Secondary opaques are found along rims and cracks in pseudomorphs after ferromagnetic minerals. As a rule, the secondary minerals dominate, feldspar is the best preserved primary mineral. Description of sampled localities follows below.

Näsby (NB), VB 263687: In the creek valley east of the road bridge in Näsby, E Tolånga, a dyke, 1 m wide, was sampled. It strikes N 60°W. The exposed and sampled area is about 2 m². The melaphyre dyke here is the best preserved of the four sampled.

Tolånga (TO), VB 249674: Two parallel dykes in the Tolånga rivulet valley were sampled. They are each 1 m wide, strike N 52°W and are situated 10 m apart. This rock is much altered and the only fresh minerals found are feldspar and opaques.

Rövarekulan (RK), VB 061841: This melaphyre is exposed in the walls in the canyon formed by the Bråån rivulet at Rövarekulan, 5 km S the lake Östra Ringsjön. The dyke is 1-2 m wide and strikes N 65°W. Samples were taken in both walls about 200 m apart. The rock is similar to that from Tolånga. There are secondary cracks filled with calcite and quartz.

Drakakull (DK), VB 058878: In the valley Pinedalen 2 km SSW of the lake Östra Ringsjön is an exposure of brecciated melaphyre which consists of fragments of shale in a mixture of melaphyric material, quartz, and calcite. The melaphyre

substance is completely altered to chlorite and calcite. The exposed and sampled area is about 2 m².

2. The Frualid melaphyre

Frualid (FD), VB 165723: This is a ridge, 1.5 km long, situated 2 km E of the northeastern corner of the lake Vombsjön. The ridge trends WNW and dips steeply down from a height of about 30 m on the northern side. It is doubtful, whether the formation is a steep dyke or a sill that slopes gently southwards. The exposed width of the ridge is about 300 m. The rock outcrops along the northern precipice and in a few exposures on the crest. Samples were collected at four sites along the escarpment and at one place on the crest. They are numbered from east. FD2 is the crest site. The formation is described by Tullberg (1882), Törnebohm and Hennig (1904), and Veldi (1951).

The rock is red-brown, dense to fine-grained and with large parts filled with amygdaloids. The texture is subophitic. The main minerals are plagioclase and opaques. The former occurs in two generations, phenocrysts and in the groundmass. Its composition varies between An₆₅ and An₇₅ for the larger grains, and between An₅₄ and An₆₀ for the smaller (Veldi, 1951). Pyroxene exists both as phenocrysts and in the groundmass. Pseudomorphs after olivine are found and consists of serpentine, chlorite, iddingsite, and ore, mainly hematite. The opaques consist of magnetite largely oxidized to hematite and limonite. Calcite and chlorite are common in the groundmass. The amygdaloids are composed of calcite, chlorite, and sometimes quartz, they often have an outer rim of limonite. Contacts with the country rock are not exposed, but in a sandstone quarry, Helvetesgraven, 1 km E Frualid, small dykes of rocks similar to the Frualid melaphyre have been found. The sandstone in which they intrude, the Öved sandstone is of Upper Silurian age. Those exposures are not available at the present. Further, fragments of the sandstone are reported to have been found in the Frualid melaphyre (Regnell, 1960).

3. The basic dykes at Torpa Klint

Torpa Klint (TK), VB 165714: This is a gneiss quarry 1 km S Frualid, in the small Precambrian horst Torpa Klint, where a swarm of thin basic dykes are exposed. There are 11 exposures of which 7 were sampled (fig. 2). The dykes vary in width from half a metre to one and a half metre. Their strike varies from N 80°E to N 10°W, the dip is between 50°-70° S-WSW. Probably a few of the dykes found in the eastern wall of the quarry pinch out towards W. The different rock types in the quarry are described by Hjelmqvist (1939).

The basic dykes vary in composition, the best preserved are similar to the least altered melaphyres of the Tolånga type. It is a dark, dense to fine-grained rock with phenocrysts of pyroxene up to 5 mm in size. Hjelmqvist calls the best preserved variety augite porphyrite. The groundmass consists of hornblende, apatite, opaques, and brown devitrified glass. The opaques are titanomagnetite and some pyrite. There are pseudomorphs after olivine that consist of serpentine, chlorite, and calcite. Amygdaloids filled with calcite are common.

In the same dyke transitions from a melaphyric center to a kullaitic margin can be found. The change to kullaite is marked mainly by an increase of nodules of red-pigmented alkalifeldspar, and of andesine in the groundmass together with delessite and epidote.

The country rock in Torpa Klint is a fine-grained granite-gneiss with pegmatitic parts. There is also a dyke of heavily altered amphibolite.

4. The kullaite and the syenite porphyry

All kullaite dykes are found in the Precambrian basement. The rock type was first mentioned by Törnebohm (1877), and later Hennig (1898) who described its occurrence on Kullaberg and named the rock after the locality. Hjelmqvist (1930, 31, 34), found similar rocks on the horst Romeleåsen, and

he has also (1939) made an account of the variety, the syenite porphyry dyke found in the quarry at Torpa Klint.

The kullaite is a red to brown fine-grained rock with ophitic texture. The main minerals are potassium feldspar, andesine, chlorite (delessite), and, as secondary minerals, pyroxene, epidote, apatite, and titanomagnetite. The feldspars are partly pigmented by a red dust, probably hematite, which sometimes gives the rock a brick-red colour. The syenite porphyry has, in addition, phenocrysts of biotite and anorthoclase. Biotite also occurs in the groundmass. Sampled localities are described below:

Kullaberg, northern side (KBN), UC 444425: This dyke is situated at Josefinelust, on the northern shoreline of the horst Kullaberg. It is a dyke 2 m wide, that strikes N 70°W and stands vertical. It was sampled at four places along a length of 80 m.

Kullaberg, southern side, (KBS), UC 423425: This dyke is situated at Wallengren's cave, on the southern shoreline of the horst. It is 4 m wide, strikes N 75°W and is vertical. Samples were collected at three places 15 m apart.

Torpa Klint, the syenite porphyry (TKS): The syenite porphyry dyke transverses the quarry at Torpa Klint (fig. 2), and is exposed at five places of which two were sampled. The dyke is 5 to 10 m wide, strikes between N 55° - 80° and dips 65°SW.

As seen, the Tolånga melaphyres and the kullaite are related, with the basic dykes in Torpa Klint as a connecting link. Hjelmqvist (1939) assumes that the melaphyre magma has been characterized by a large amount of water which is the reason for the autometasomatic alterations of the original mafic minerals. The pyroxene and olivine in the Tolånga type melaphyres are altered to serpentine and chlorite, while in the kullaite the pyroxene and olivine are replaced by epidote, delessite and carbonate. Further, the active water-

rich solutions in the melaphyre magma have influenced the different types of country rock and in turn been influenced by them. Veldi (1951) attributes the high oxidation state of the Frualid melaphyre magma, exemplified by the high hematite content, to the magma's penetration and assimilation of the highly oxidised Öved sandstone.

In his description of the rocks in the Torpa Klint quarry, Hjelmqvist describes how original gneiss fragments, that are found in the basic dykes, have been syenitized, and he considers a similar origin for the syenite porphyry dyke: "... the syenite porphyry dyke in Torpa Klint has the same origin as the syenite porphyry fragments, i.e. that it is a regenerate part of the granite-gneiss melted by the basic magma and then - as a result of tectonic influences - pressed upwards as a comparatively thick dyke in the rock above". (op. cit. p 15). The syenite porphyry is then the end product of the series melaphyre - kullaite - syenite porphyry.

Basalts

Many authors have described the Scanian basalts. Among them Norin (1933, 34) has given a description of their petrology, Nathorst (1887) and Börlau (1966) have studied the basalts in connection with the tectonics of Scania, and recently Printz-lau and Larsen (1972) published the results from radiometric age determinations of the basalts.

The bedrock in the area N and NW of the lakes Ringsjöarna, where the basalts outcrop, is composed of Precambrian gneisses and Mesozoic sediments. The basalts are the solid remains of volcanic vents where erosion has removed the overburden. At a few localities tuffaceous remnants are found. In the terrain the basalts are found as rounded or oblong hills and hillocks that vary in height from a few metres to fifty metres above the surrounding area. Columnar jointing is common with vertical pillars in the centre and a change to flat lying towards the margin. The best exposures are generally found in the upper part of the hills as the lower parts are hidden

below talus and drifts, That means that sampling occasionally was done in areas exposed to lightning. Contacts with the country rock have never been found except in drill holes.

The rock is a porphyritic alkalibasalt with phenocrysts of olivine and titanogaugite in a groundmass of plagioclase, mainly labradorite, titanogaugite, titanomagnetite, and glass. Minor constituents are nepheline, biotite, sphene, and picotite. Secondary alteration products such as zeolite, chlorite, epidote, and calcite are sometimes found.

Below follows a description of sampled localities from E to W:

Espet (ES), VC 216183: This is the most northernly basalt occurrence. It forms a hillock 6 km S Hässleholm. The rock has columnar structure with pillars dipping 30° S. The olivine is serpentized along cracks. Zeolites are found in amygdaloids. Samples were collected in a road-cut over a distance of 30 m.

In the area around Häglinge, 12 km N Östra Ringsjön, three basalt occurrences were sampled. From north to south they are: Snababerg, Lönneberg, and Göbnehall.

Snababerg (SB), VC 179087: The sampled exposures are found on the eastern side of the hill Snababerg. Samples were collected at three sites 50 m apart. The basalt has columnar structure with pillars dipping 30° to 60° S. The rock is well preserved.

Lönneberg (LB), VC 179088: Lönneberg is one of the largest basalt occurrences in Scania. There are many exposures, and sampling was done on the eastern side of the hill in six sites on a line from the top and downwards. The basalt has columnar jointing with varying directions for the pillars. The olivine is partly serpentized and zeolites are found.

Göbnehall (GH), VC 172042: At Göbnehall there is a quarry in a volcanic neck. Rounded structures from where pillars diverge fanwise are found at the bottom of the quarry. Samples were collected at three places 50 m apart. The olivine and the pyroxene are somewhat altered. There are zones with zeolites which were avoided in the sampling.

Anneklev (AK), VC 101009: This is an isolated hill 4 km N Östra Ringsjön. Basalt is exposed in the upper part of the hill and samples were collected at two places 30 m apart. The rock is columnarily jointed with vertical pillars. The olivine and pyroxene is partly altered. As secondary minerals zeolite, epidote, and chlorite are found.

In the centre of the basalt area, about 10 km N Västra Ringsjön, three outcrops were sampled. They are from north to south: Säte-N Rörium, Hästhallarna, and Ulfsberg.

Säte-N Rörium (SR), VC 057096: In this hill the basalt is best exposed in the northern side where samples were collected in an exposure 2 m² in size. The rock is columnarily jointed with vertical pillars. The olivine is almost unaltered but the pyroxene is corroded. Calcite was found as an alteration product and some quartz was observed.

Hästhallarna (HH), VC 071066: At this occurrence there are good exposures on the SE side of the hill and there are a few small exposures 200 m E. Samples were collected at both exposures. Sample spread at the larger site was 100 m, at the other a few metres. The basalt at the collecting sites is columnarily jointed with pillars dipping flatly towards N. The olivine is slightly altered. Zeolites occur.

Ulfsberg (UB), VC 041046: Here samples were collected at two places 300 m apart, along the southeastern and the northeastern escarpment of the hill. At each locality sampling was done along a distance of 30 m. Sampling and measuring was done by Musa Güner (1972). The olivine is altered along

cracks and the pyroxene is corroded. Zeolites are found.

In the western part of the basalt area, about 25 km NW of Ringsjöarna, three localities were sampled. They are from north: Juskushall, Bonarp-Ljungbyhed, and Rallate.

Juskushall (JH), UC 947172: This is an oblong hill with basalt exposed at a precipice at the northern end and also 150 m south thereof. Samples were collected at both sites. The basalt has columnar jointing with vertical pillars. The olivine is altered to serpentine along cracks.

Bonarp-Ljungbyhed (BL), UC 878164: This is the most westernly occurrence. The rock is irregularly jointed. Two sites 150 m apart were collected. The olivine is slightly serpentinized. Large crystals of zeolite are common.

Rallate (RA), UC 920106: This is the smallest occurrence sampled. The basalt forms regular pillars that dip 30° S. Samples were taken in an area of 2 m^2 . The olivine is slightly altered and some zeolites were found.

Längenåbbe (LN), VB 023969: This exposure is situated on the western shore of the lake Västra Ringsjön. It differs from the other basalt occurrences both in field appearance and in petrology. It is a 10 m wide dyke that juts out into the lake. It strikes $N 60^{\circ}W$. Sampling was done along the northern edge in an area of 5 m^2 . There is no olivine, and there are not any pyroxene phenocrysts, the SiO_2 content is higher and the MgO lower than in the alkalibasalts (from analyses by Norin, 1933). The rock has a subophitic texture. Norin (1933) included this occurrence in his study of the Scanian basalts and he also mentions the petrological differences.

Höör sandstone

For testing the sensitivity of the measuring apparatus some cores were drilled in a sandstone quarry with Höör sandstone.

The samples contained a weak but measureable magnetism. As the sandstone and the basalts occur in the same region and could be of similar age, it would be of interest to include the sandstone results in this study.

The Höör sandstone is described, among others, by Hadding (1929) and Troedsson (1940).

Stanstorpagraven (SG), VD 071975: The cores were drilled in an area of 5 m², on the same level in the quarry. The strata are horizontal. The sandstone is a white to yellowish, nearly pure quartz sandstone with a few grains of feldspar and muscovite. The opaques are mainly distributed as a fine pigment in the matrix.

Age relations

The Post Cambrian dyke system in Scania, which comprises the quartz dolerites and the melaphyres, have been considered to be of Lower Permian age (Hjelmqvist, 1939). For the quartz dolerites the possibility of Upper Silurian age has been proposed (Törnebohm and Hennig, 1904, Regnell 1960). This is based on the fact that they have never been found in rocks younger than the lower Ludlovian Colonus shale. The melaphyres are found intrusive in the Upper Silurian Öved sandstone, so they are certainly Post Silurian. Mulder (1971) reports K/Ar data from dolerite sills in the eastern and western parts of Västergötland. The ages reported are 287 ± 15 m.y. and 279 ± 8 m.y. respectively. He has also done paleomagnetic measurements on those sills together with quartz dolerite dykes from Scania. The paleomagnetic results from Västergötland and Scania coincide rather well (table 5), indicating contemporary age. Recently, K/Ar determinations of the Scanian dyke system has begun at the Laboratory for Isotope Geology in Stockholm. Preliminary results from dyke occurrences sampled along a line Kullaberg-Simrishamn give an isochrone age of about 250 m.y. (Klingspor, in preparation). Included in those measurements are quartz dolerites, melaphyres from Tolånga and Fruålid, and basic dykes and the

syenite porphyry in the quarry at Torpa Klint.

Previously the Scanian basalts have been considered to be of Tertiary age, mainly due to the presence in neighbouring areas of volcanics of that age: Ashlayers in Eocene sediments in Jutland, volcanic Tertiary rocks in Poland and Germany.

Scanian basaltic lavas and tuffs have in borings been found to overlay Liassic sediments (Börlau, 1966). Printzlau and Larsen (1972, and pers. comm.) have K/Ar dated 18 basalt occurrences. Their data can roughly be divided into three groups, approximately 80 m.y., 120 m.y., and 150 m.y., which implies that the volcanism started in the Jurassic and continued into the Cretaceous. They consider that some of the reported ages are too low, as a number of the measured samples with ages around 80 and 120 m.y. had a fairly high content of glass, which suggests argon losses for those specimens. Samples from the basalt quarry at Göbnehall have been dated by Klingspor (1973), a preliminary isochrone age is 163 m.y. Printzlau and Larsen present an age of 131 ± 8 m.y. for a sample from the same occurrence.

An occurrence of basaltic tuffaceous material has been found at the lake Korsarödsjön, 3 km ENE Göbnehall. Micro pollen and spores found together with petrified wood in the tuff has preliminarily been dated by Tralau (pers. comm.) to the Upper Lias - Lower Dogger.

The Höör sandstone is of Lower Lias age (Brotzen, 1962).

ORE PETROLOGY

In this section are considered the opaque minerals which are the carriers of the remanent magnetism. The main magnetic minerals in rocks are those that belong to the titanomagnetite series and to the hematite - ilmenite series.

The titanomagnetites are ferrimagnetic. The end members in the series are Ulvö-spinel, Fe_2TiO_4 and magnetite, Fe_3O_4 .

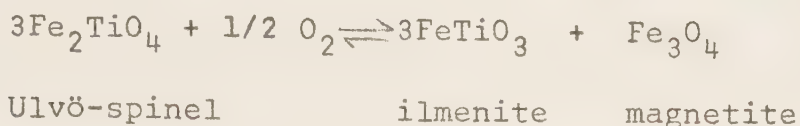
They are in solid solution above 600°C with a tendency to exsolve below that temperature. The Curie temperature for pure magnetite is 578°C and -170°C for pure Ulvö-spinel. There is a linear relationship and the Curie temperature reaches room temperature at a composition of 80 percent Fe_2TiO_4 (Nagata, 1961, p 82). This means that titanomagnetites towards the magnetite end are of paleomagnetic interest.

The hematite - ilmenite series form a solid solution above 1050°C . On cooling it almost always exsolves into intergrowths of hematite and ilmenite. Hematite is important in paleomagnetic studies as it carries a weak but stable parasitic magnetism. Its Néel temperature is 675°C . Ilmenite is paramagnetic at room temperature.

The size of magnetic grains is of importance. Larson et al. (1969), studied the coercivity spectra for a range of rock types with titanomagnetite of varying grain size. It was found that rocks with grains in excess of $10\mu\text{m}$ are magnetically soft while rocks with grains mostly less than $10\mu\text{m}$ are hard. They also found that a large part of the magnetic grains in the fine grained rocks were in size below the resolving power of the optical microscope, which means they were less than $0.5\mu\text{m}$. Evans and Wayman (1970) studied the size distribution of magnetite grains in a basic igneous intrusion by means of electron microscopy. They found that the distribution had a peak at about $0.25\mu\text{m}$. This is in the area given by Dunlop (1972) for multidomain particles that have a stable thermoremanent magnetization like that of single domain particles. These are considered to have stable magnetism and large coercivity (Strangway, 1970, p 139, Tarling, 1971, p 13).

The grain size depends on cooling conditions during crystallization and on oxidational changes after consolidation. A high-temperature oxidation phenomena is the formation of ilmenite exsolution lamellae in the initial titanomagnetite grains. This depends on oxygen fugacity and the contents of volatiles, mostly water. The following equa-

tion is an approximation of the oxidation of titanomagnetite (Ulvö-spinel) in a basalt during cooling:



Magnetite and ilmenite are structurally different so a formation of ilmenite lamellae occurs. These lamellae divide the grains into areas of magnetite that occasionally are less than $0.25\mu\text{m}$ and accordingly increase the magnetic stability of the grains.

Continued oxidation of the titanomagnetites occurs at lower temperatures due to circulating groundwater and weathering. The alteration goes from titanomagnetite to titanomaghemite and hematite. Further, titanomaghemite, which is an unstable phase, tends to change to hematite and rutile (Larson et al. 1969, p 282). The implications of these on the remanence of the rocks are a stable magnetism due to subdividing of large grains into smaller stable ones and the formation of the stable mineral hematite. The latter imposes on the rock a stable CRM. If the geomagnetic field has changed direction between the rocks consolidation and the formation of the hematite there will be changes in the magnetic directions of the rock, which will have to be considered.

A mottled texture was found in some titanomagnetite grains. This phenomenon is so fine that it was not possible to study it in detail with the microscope. A similar texture has been described by Ade-Hall et al. (1968, p 378), in a study of a lava from Skye, Scotland. They explain it as a low temperature phenomenon, and, through X-ray studies, they found it was composed mainly of impure rutile. They call this type of texture for titanomagnetite granulation. They did not find any paleomagnetic complications due to granulation in their study.

To study the opaques, polished sections together with thin sections, were prepared from all sampled rock types. The polished sections were studied with an ore microscope, largest magnification 1050 times, oil immersion. Below follows a short description of the opaques in the different rock types.

Quartz dolerites

The opaques consist generally of titanomagnetite with ilmenite in lamellae and in spots. Other ores found are separate ilmenite grains and occasional sulphides, mainly pyrite. The grain size varies depending on how close to the contact the sample was collected, but they are in the range 50-100 μm . The ore content is between 8 and 14 weight percent.

Melaphyres

1. The Tolånga type: There are two generations of titanomagnetite in this rock. Ilmenite is not found in any of them but some grains show granulation. The primary grains are 25-30 μm in size while the secondary are 5 μm or less. The latter are found in cracks and along rims of pseudomorphs after olivine and pyroxene. Some fine grains of pyrite are found. The ore content is between 2 and 10 volume percent according to point count analyses.

2. The Fruålid melaphyre: This rock is very rich in opaques, point count analyses gave 30-40 percent of ore. They occur as euhedral grains, intergrowths and irregularly along cracks. The primary ore mineral seems to have been magnetite forming euhedral grains. They are now mainly oxidized to hematite. Generally, more than 70 percent of the original magnetite is changed to hematite leaving only patches of magnetite 2-5 μm in size. The average grain size is 50-100 μm . In addition there occur irregular hematite and limonite grains as secondary alteration products of feric minerals.

3. The basic dykes at Torpa Klint: There are two generations of titanomagnetite. Most grains are granulated. Leucoxene is

common around the titanomagnetites. The primary grains range in size between 25-50 μm , and the secondary are 5 μm or less. They are found as alteration products after olivine and pyroxene. Small pyrite grains are common and a few grains of hematite are found. Point count analyses gave 6-9 volume percent of ore. No difference has been found in ores between the dyke parts similar to the Tolånga type melaphyres and those similar to the kullaite.

4. The kullaite and the syenite porphyry: The opaques in the kullaite from Kullaberg consist of titanomagnetite. They are granulated and corroded and occur in irregular grains. They are often surrounded by leucoxene. The grain size varies between 10-70 μm . The ore content is 10.5 weight percent according to an analysis by Hennig (1898). The opaques in the syenite porphyry from Torpa Klint consist mainly of titanomagnetite. Some grains are partly or wholly granulated. Pyrite is found in small amounts. The grain size of the titanomagnetites varies considerably, from 10 to 300 μm . The ore content is 2.6 weight percent according to an analysis given by Hjelmqvist (1939).

Basalts

The opaques in the basalts consist of titanomagnetite. They do not show any sign of high temperature oxidation. The exception is a polished section from Hästhallarna, where ilmenite lamellae and patches were found in some large grains. A few grains of pyrite were also found in that section. The grain size in the basalts varies between 4-40 μm , with the smaller grains prevailing. The ore content varies between 6 to 17 weight percent according to analyses given by Norin (1933, 34).

The titanomagnetites in the Långenåbbe occurrence differs somewhat from the above mentioned. There are two distinct ranges of grain size, one 3-9 μm , the other 30-100 μm . The smaller grains cluster together in skeletal textures.

X-ray measurements

X-ray diffraction measurements were done on samples from 7 sites: The melaphyres Torpa Klint 9 and Rövarekulan, and the basalts Göbnehall, Lönneberg, Hästhallarna, Juskushall, and Långenäbbe. The samples were crushed and screened and from a fraction 140-200 mesh a magnetic part was separated with a hand magnet. The diffraction curves obtained were complex but all show peaks of a cubic phase with lattice parameters between 8.39-8.50 Å which suggest members of the magnetite-Ulvö-spinel series (Basta, 1960). Comparison was made with a diffraction curve from a sample of Ulvö-spinel from Ulvön which gave a similar pattern. In the melaphyre samples were also found peaks that indicated the presence of maghemite, hematite, and titanium oxides. The X-ray results thus roughly agree with the ore microscopy examination.

SAMPLING AND MEASURING METHODS

Oriented core samples were obtained with a small petrol-powered watercooled diamond core drill (Doell and Cox, 1967). Orientation was done with the cores still fix in the ground and with a device similar to that described by Brown and Khan (1967). The azimuth of the core axis was measured by magnetic compass and supplemented by sighting. Generally the differences between measurements with compass and sighting were only a few degrees, but in the few cases when the differences were larger, up to 10° due to magnetic disturbances from the outcrop, the sighted values were used for calculations. The dip of the core was measured with a protractor.

The obtained cores were from 5 to 10 cm long. It was generally difficult to drill deeper because of the often heavily fractured exposures. From the bottom end of the core one specimen 2.3 cm long was cut. The diameter of the core was 2.5 cm. The rest of the core was used for polished and thin sections.

The purpose was to get at least six cores from each drill site to obtain a reasonable number for the statistical calculations (Doell and Cox, 1963). In a few cases, fewer cores were recovered due to fractured and friable rock. When possible samples were collected in road cuts and quarries and the intention was to get as unweathered specimens as possible.

The properties measured and calculated were:

1. The direction of the NRM expressed by declination and inclination.
2. The intensity of the NRM (J_n) measured in emu/cm^3
3. The susceptibility χ gauss/oersted
4. Q (the Königsberger ratio), the ratio between the intensity of the NRM to that induced in the specimen by the present magnetic field (H_o) at the collecting site or laboratory.

$$Q = J_o / \chi H_o$$

For H_o was used the value 0.49 gauss, the intensity of the vertical component of the present geomagnetic field in the laboratory in Lund.

For measurement of the direction and intensity of the remanent magnetization a four probe fluxgate magnetometer (Förster Oersted meter), and an UFG-JR3 spinner magnetometer were used. The latter was built at the Institute of Applied Geophysics in Brno, Czechoslovakia. In the fluxgate unit the specimen was measured in 24 positions from which the average intensity and direction were calculated, in the spinner unit it was sufficient to measure 8 positions. The range of the most sensitive of those instruments, the spinner unit, is $8 \times 10^{-3} \text{ emu/cm}^3$ to $8 \times 10^{-7} \text{ emu/cm}^3$.

For susceptibility measurements either the fluxgate unit or a commercial susceptibility bridge, Soiltest MS-3 were used. In the latter the whole core was measured before it was cut into specimens.

To remove unstable viscous components, demagnetization in alternating field was used. The original NRM in the rock will decrease during geological time, viscous decay, and, at the same time, a new magnetization may be acquired at temperatures below the Curie temperature, viscous remanent magnetization (VRM) (Irving 1964, p 32). This secondary magnetism is often unstable with a low coercive force and is often possible to remove. It is frequently found to be parallel with the present geomagnetic field.

The principles behind alternating field demagnetization is based on the tendency for the magnetic domains with coercive force lower than that given by the peak alternating field to follow the field as it alternates. The field is slowly and continuously reduced. During the process the weak domains will become fixed in directions that are governed by the structure of the magnetic minerals. If the specimen is isotropic the orientations will be random and the magnetic domains will cancel each other. The best results are achieved if the specimen can rotate in all directions during the procedure, and this can be done with a tumbler device. Trials were done with a rotating apparatus, but due to the small diameter of the demagnetizing coil it was difficult to make it work properly. It was found that the same result was accomplished if the demagnetization was done in three rounds with the specimen in three perpendicular directions. With the coil used it was possible to obtain a demagnetizing field of 1000 oersted. Anhysteretic remanent magnetization caused by the Earth's magnetic field was cancelled by a set of Helmholtz coils.

From each site at least one specimen was measured in demagnetization steps of 50 oe up to 500-800 oe. When it was found that the magnetic directions did not change during continued demagnetization in at least three successive steps it was considered that the soft magnetic components were removed and only a stable component remained. From these results it was decided how to demagnetize the rest of the

specimen from that site. Generally this was done in 3-4 steps to a peak field of 400 oe.

For all necessary calculations a programable Hewlett-Packard 9100B desk calculator was used.

The combined errors in sampling and measuring are estimated to be below 5°.

MAGNETIC STABILITY OF MEASURED ROCK TYPES

Below follows a discussion of the stability of the magnetic remanence in the measured rock types. In diagrams the ratio J_0/J against the used peak demagnetizing field are plotted. J_0 is the intensity of the initial remanence and J that measured after demagnetization in the applied field. These diagrams give a measure of the coercive forces of the magnetic minerals that carry the remanence. A rapid decrease implies the presence of minerals with low coercive force and subsequently unstable remanence. For example see TK 6 in fig. 13. Contrarily, minerals with high coercivity, e.g. hematite, give curves with slow decrease (Nagata, 1967). Examples of this are found in fig. 10. Commonly the decay curves show a combination of both types of behaviour, with a rapid initial decrease when the soft components are removed, after which the curve flattens out due to the 'hardness' of the remaining magnetic components. Examples of decay curves are given from each sampled site.

The magnetic directions before and after demagnetization are plotted in equal area projections. Open figures refer to reversed (upward) inclination, and closed figures refer to normal (downward) inclination. The after demagnetization values plotted represent the demagnetizing level with least scatter in directions.

If a Q-value is below unity the induced magnetism in the sample is larger than the remanence. It has empirically been

found that when this is the case the sample generally has low magnetic stability, but this is a rule with exceptions as reported by van Everdingen (1960, p 57).

Quartz dolerites

The intensity of the NRM was $1 \times 10^{-3} - 8 \times 10^{-3}$ emu/cm³, and the Q-values well above unity with the exception of the specimens from Simrislund and Tomelilla-Ullstorp, which gave Q-values from 0.5-1. Most quartz dolerite specimen displayed a remaining stable remanence after demagnetization in peak alternating field of 200-300 oe. The specimens from Simrislund and Bollrup exemplify how the magnetic directions are clustered together after demagnetization from dispersed initial directions (fig. 4, 5). This indicates the presence of a soft viscous magnetic component which is removed after treatment in an alternating magnetic field. Other dykes, e.g. Hardeberga, Rönnarp-Tågarp present small changes in direction during demagnetization, which means that the initial NRM is identical with the stable remanence (fig. 6). Exceptions from the stable behaviour are seen in the specimens from Tomelilla-Ullstorp and to a lesser degree in those from Simrislund. The first mentioned presented during demagnetization a large within specimen scatter in directions. The low Q-value and the rapid decay in intensity during demagnetization suggest that the minerals that are carriers of the NRM have a low coercive force. The inclination of those specimens points downwards in contrast to the other quartz dolerite specimens. For the Simrislund specimens it is possible that weathering effects are responsible for the low stability. Demagnetizing curves and magnetic directions are given in fig. 3-6.

Melaphyres

1. The Tolånga type: Of the four dykes sampled and measured only two contained specimens with stable remanence, Rövarekulan and Drakakull and even in these some specimens were unstable. All four dykes had low Q-values, about 0.3. The NRM was low, $1 \times 10^{-5} - 7 \times 10^{-5}$ emu/cm³ for all except the Näsby specimens which had a mean NRM of 1×10^{-3} emu/cm³.

The decay curves (fig. 7) show a rapid decrease for the unstable Näsby and Tolånga dykes. Demagnetization curves and magnetic directions are given in fig. 7-9.

2. The melaphyre in Fruålid: All Fruålid specimens displayed stable remanence and consistent directions after demagnetization. The sites FD 4 and FD6 showed the presence of soft components. Initial NRM varied between 3×10^{-5} - 50×10^{-5} emu/cm³, the Q-values between 1-2. The low decay rate during demagnetization implies that hematite is the carrier of the remanence. Demagnetization curves and magnetic directions are given in fig. 10-12.

3. The basic dykes in Torpa Klint: All specimens exhibited the presence of a soft magnetic component which was removed during demagnetization. A high scatter was present both within and between the specimens from dyke TK 6. The low stability in this dyke is further exemplified by its high decay rate (fig. 13). The Q-values in the basic dykes varied from 0.3 to 0.9. The initial NRM is 0.2×10^{-3} - 3×10^{-3} emu/cm³. Demagnetization curves and magnetic directions are given in fig. 13-16.

4. The kullaite and the syenite porphyry: Of the 17 kullaite and syenite porphyry specimens measured only 6, all from Kullaberg, had a stable remanence. The directions between specimens show a high degree of scatter. The initial NRM varies from 2×10^{-5} - 70×10^{-5} emu/cm³. The Q-values are around unity, the remanence decays rapidly during demagnetization. Demagnetization curves and magnetic directions are given in fig. 17-18.

As seen the magnetic behaviour is rather unpredictable for the melaphyres. They are all altered rocks, the original mafic minerals are changed to serpentine and chlorite and there is secondary formation of opaques. No difference has been found in the ore mineral composition that can explain the variations in magnetic stability. The exception is the

Frualid melaphyre where a high degree of oxidation of magnetite to hematite could explain the stable remanence. Another indication of the low stability in the melaphyres, except Frualid, is that they acquired an anhysteretic magnetization during demagnetizing tests in higher fields, 600 - 1000 oe. This was displayed by abrupt changes in direction and magnitude of intensity. It is possible that due to imperfections in the demagnetization apparatus there existed weak stray magnetic fields which affected the unstable magnetic minerals in the melaphyre specimens. This phenomenon was not observed in the other rock types.

Basalts

Most of the basalt specimens presented the common pattern of a soft magnetic component which was removed during demagnetization and a remaining stable component. The Q-values vary from 1 to 40 and the initial NRM from 2×10^{-3} - 25×10^{-3} emu/cm³. The specimens from Juskushall are an exception. Of seven measured only two had stable magnetization. The Juskushall samples were collected near the highest point of the hill and it is possible that secondary effects caused by lightning are responsible for the instability. Demagnetization curves and magnetic directions are presented in fig. 19-26.

The secondary alterations that are found in the basalts, the formations of zeolite, epidote, calcite, and chlorite, do not seem to have affected the titanomagnetites and their magnetic stability.

Höör sandstone

The sandstone displayed the presence of a stable remanence during demagnetization. The NRM was weak, around 1×10^{-6} emu/cm³, close to the lower sensitivity range of the spinner magnetometer. It was not possible to measure the weak susceptibility with the equipment available so no Q-value was calculated. Demagnetization curve and magnetic direc-

tions are presented in fig. 27-28.

PRESENTATION OF RESULTS

The results of the measurements are given in tables and diagrams. In the tables the directions after demagnetization are presented. There a/b gives the number of specimens with stable magnetization (a) compared with the number of specimens measured (b). The directions are given as the declination (decl) measured clockwise from geographic north, and the inclination (incl) measured from the horizontal, positive when directed downwards. k is the best estimate of Fisher's (1953) precision parameter K for points distributed on a sphere. K varies from zero for a perfectly random distribution to infinity for identical directions. α_{95} is the radius of a circle on the surface of a sphere, centered on the observed mean direction and calculated so there is one chance in twenty that the true mean direction will be outside the 'circle of confidence' given by α_{95} . The formulae for the calculation of k and α_{95} are given below:

$$k = \frac{N - 1}{N - R}$$

$$\cos \alpha_{95} = 1 - \frac{N - R}{R} \left\{ \left(\frac{1}{P} \right)^{\frac{1}{N - 1}} - 1 \right\},$$

where N is the number of measurements used, in this paper = a ,
 R is the length of the resultant vector when unit weight is given to the magnetic vector for each specimen or site,

P is the probability level required, usually 95 percent.

Thus a high value for k and a low value for α_{95} indicate a high degree of reliability. In the present paper it is assumed that a value for k less than 10 and higher than 15° for α_{95} indicate a too large scatter of directions and sites with such values are not included in the calculations of pole positions.

From the site mean directions are computed the virtual geomagnetic pole (VGP), in present geographic coordinates. The VGP is the pole calculated from sequences of rocks that represent a shorter interval of magnetic field variations. A paleomagnetic pole is calculated from the mean directions of the fossil magnetism measured in a sequence of igneous or sedimentary rocks and which is assumed to represent an axial dipole field (Creer, 1970, p 373).

d_m and d_p given together with the pole coordinates are the axis in an 'ellips of confidence' around the pole nearest to the sampling site, with d_m along the mean declination (Talling, 1971, p 81). d_m and d_p are calculated from the formulae:

$$d_m = \alpha_{95} \sin \Psi / \cos \bar{I}$$

$$d_p = 1/2 \alpha_{95} (1 + 3 \cos^2 \Psi)$$

where Ψ is the angular distance of the mean pole from the sampling location.

$\bar{I}$ is the site mean inclination.

Table 1. Quartz dolerites, magnetic directions

Site	a/b	decl	incl	k	α_{95}
Simrislund	4/6	190°	-1.5°	53	12.55°
Bollerup	6/6	205.5°	-25°	127	5.5°
Tomelilla- Ullstorp	0/7	-	-	-	-
Dalby 1	17/18	202.5°	-16.5°	39	6°
Dalby 2	6/6	193°	-7°	339	3.5°
Hardeberga	12/12	191°	-22°	195	3°
Röstånga mölla	12/12	194.5°	-3°	68	5°
Rönnarp-Tågarp	15/15	202.5°	-13°	66	5°
Mean, sites	7/7	197°	-12.5°	54	8°
Mean, specimen	72/82	198°	-14°	21	4°

Calculated pole position (VGP),

	lat	long	d_m	d_p
Sites	39°N	172°E	8°	4°
Specimens	39°N	170.5°E	4°	2°

Corresponding data are plotted in fig. 29, 31, 33.

Table 2: Melaphyres, magnetic directions

Site	a/b	decl	incl	k	α_{95}
Tolånga type					
Näsby	0/5	-	-	-	-
Tolånga	0/4	-	-	-	-
Rövarekulan	4 5/6	180°	-33°	88	10°
Drakakull	5/7	178.5°	-47°	79	9°
Mean, sites	2/2	179°	-40°	-	-
Mean, specimens	9 10/24	179°	-41°	52	7°
Frualid					
FD 1	6/6	204°	16°	299	4°
FD 2	6/6	208.5°	6°	107	6.5°
FD 4	6/6	211°	15.5°	40	11°
FD 5	6/6	202°	17.5°	527	3°
FD 6	5/6	220°	15°	56	10°
Mean, sites	5/5	209°	14°	98	8°
Mean, specimens	29/30	212°	17.5°	14	4.5°
Torpa Klint, basic dykes					
TK 2	4/4	208°	-14.5°	906	3°
TK 4	6/6	199°	-25.5°	372	3.5°
TK 5	5/5	202.5°	-37.5°	451	3.5°
TK 6	0/5	-	-	-	-
TK 7	11/11	191°	-49°	142	4°
TK 8	7/7	190°	-32°	1923	1.5°
TK 9	7/7	184.5°	-59°	377	3°
Mean, sites	6/6	197°	-36.5°	22	15°
Mean, specimens	40/45	195°	-40.5°	29	4°
Kullaberg					
KBN	4/6	280°	73.5°	19	22°
KBS	2/6	258.5°	63°	-	-
Torpa Klint, syenite porphyry	0/5	-	-	-	-

table 2, cont.

Calculated pole positions (VGP),

	lat	long	d_m	d_p
Tolånga, type, specimens	57.5°N	165°W	40	31
Frualid, sites	22.5°N	162°E	8	4
Frualid, specimens	20°N	160°E	10.5	5.5
Torpa Klint, basic dykes, sites	52°N	167°E	17	9
Torpa Klint, basic dykes, specimens	55.5°N	169°E	10.5	5.5

Corresponding data are plotted in fig. 30, 31, 33.

Table 3: Basalts, magnetic directions

Site	a/b	decl	incl	k	α_{95}
Normal polarity					
Anneklev	6/6	49°	45°	35	11.5°
Espet	6/6	49.5°	36°	886	2°
Lönneberg	8/8	20°	72°	708	2°
Hästhallarna	4/6	18°	67°	380	5°
Snababerg	5/6	46.5°	74°	203	5.5°
Ulfberg	18/18	32°	60.5°	35	6°
Reversed polarity					
Bonarp	6/6	184.5°	-66.5°	300	4°
Göbnehall	7/8	237°	-62°	110	6°
Juskushall	2/7	103°	-23.5°	-	-
Rallate	6/6	272.5°	-54.5°	291	4°
Säte	5/5	311°	-78.5°	245	5°
Längenåbba	6/7	173°	-7.5°	259	4°
Normal polarity					
Mean, sites	6/6	39°	60°	23	14°
Mean, specimens	47/50	38°	60°	23	4.5°

table 3, cont.

Site	a/b	decl	incl	k	α_{95}
Reversed polarity					
Mean, sites	4/4	247°	-71°	16	24°
Mean, specimens	24/25	246°	-71°	17	7.5°
Normal and reversed combined					
Mean, sites	10/10	47°	64.5°	18	11.5°
Mean, specimens	71/75	45°	64°	19	4°

In the calculation of mean directions data from Långenäbbe and Juskushall are omitted.

Calculated pole positions (VGP),

	lat	long	d_m	d_p
Normal polarity, sites	60.5°N	118°E	20	17
" " , specimens	61°N	118°E	6.5	5.5
Reversed " , sites	54°N	76°E	42	36
" " , specimens	54°N	76°E	13	11

Normal and reversed polarity combined

Sites	59.5°N	101°E	18.5	14.5
Specimens	60°N	104.5°E	6	5

Corresponding data are plotted in fig. 32 and 34.

Table

Table 4: Höör sandstone

Site	a/b	decl	incl	k	α_{95}
Stanstorpgraven	5/5	7.5°	61.5°	35	13°
Calculated pole position (VGP),					
		lat	long	d_m	d_p
		76°N	170°E	19	15.5

Statistical tests

In the tables average values based on unit weight given to site means are given together with results achieved when unit weights are given to each specimen from the same rock type. This was done due to the low number of sites used in the statistical calculations. It was interesting to see if the specimen mean values differed from site mean values. This did not occur and the directions and poles plotted in the stereographic projections and on the maps are based on site means. Exception is the Tolånga type melaphyres for which specimen mean is used.

To prove if the magnetic directions of one formation is identical or not with the directions of another formation statistical tests have to be done. The simplest is to find out if the 'circles of confidence' intersect. If they do not the directions can be considered significantly different (McElhinny, 1967, p 317), but if they do intersect one has to use other statistical tests. In this paper the problem arises only by comparison of the directions of the Torpa Klint basic dykes and the melaphyres of the Tolånga type. All other computed directions can be considered significantly different according to their 'circles of confidence'. The tests used are described by McElhinny (1967 p 316-318). First a test is done to determine if the precision parameters k of the two groups of samples are identical. This is done by a comparative F-test of the k -values, in which the test value F is obtained from the formulae:

$$F = \frac{k_1}{k_2} = \frac{\text{variance with } 2(N_2 - 1) \text{ degrees of freedom}}{\text{variance with } 2(N_1 - 1) \text{ degrees of freedom}}$$

For the Tolånga type melaphyres $k_1 = 52$, $N_1 = 9$ (specimen) and for the Torpa Klint basic dykes corresponding values are $k_2 = 29$, $N_2 = 40$. This gives $F = 1.79$, which is not significant at the probability level $P = 0.05$. There is thus no reason for rejecting the hypothesis that the Fisherian precision parameters are the same for the Tolånga melaphyres

and the Torpa Klint basic dykes.

For testing if the two mean directions are identical the following test was used:

$$F = \frac{(R_1 + R_2 - R)}{(N - R_1 - R_2)}$$

The degrees of freedom used for this test in the F-ratio tables are 2 and 2(N - 2). R_1 and R_2 are the sum vectors of the two groups of specimens, respectively, R is the sum vector of all (N) the individual specimens. In this case $R_1 = 8.8461$ (Tolånga), $R_2 = 38.6509$ (Torpa Klint), and $N = 49$. This gives $F = 3.96$. According to the F-table the hypothesis rejected at the probability level $P = 0.05$. There is therefore reason to assume that the magnetic directions of the Tolånga type melaphyres and the Torpa Klint basic dykes are not identical.

DISCUSSION OF RESULTS

Quartz dolerites and melaphyres

These rock types all have significantly different magnetic directions but K/Ar determinations suggest that they are contemporary. The quartz dolerites are the rocks that are least altered and it is assumed that their stable remanence represents the original TRM acquired at formation. This is further confirmed by the good agreement between the Upper Carboniferous - Lower Permian pole positions listed in table 5 and the virtual geomagnetic pole calculated for the quartz dolerites.

It is probable that the magnetic directions found in the different types of melaphyres display an initial TRM masked by a stable CRM acquired through the formation of secondary magnetic minerals. The resultant magnetic vector will then be composed of the stable TRM and CRM components. The period when these rocks were formed, Upper Carboniferous - Lower Permian coincide with the Kiaman magnetic interval. This

interval, which was proposed by Irving and Parry (1963), comprises the time from the Middle Carboniferous to Middle Permian. It is a geomagnetically 'quiet' period when reversed polarity dominates. This means that secondary formation of magnetic minerals during that time would not give any considerable deviations in directions. This is applicable for the Tolånga and Torpa Klint melaphyres.

The Frua lid melaphyre has normal polarity and very stable magnetism in contrast to the other melaphyres. The high content of secondary hematite is responsible for the stability. A further complication is the possibility that part of the hematite, together with limonite, are weathering products of more recent age when the melaphyre was exposed by the fault which created the steep wall on its northern side. Rotational movements connected with this faulting could also cause deviations in the magnetic directions.

To solve the problem of one or more magnetic components and their stability in the melaphyres one has to use thermal demagnetization methods and measure the Curie temperatures of the different magnetic minerals involved.

The secular variation may contribute to the scatter in directions between different narrow dykes of the same rock type. This effect is minimized if a sufficient number of dykes are sampled, and this is assumed to be the case for this study. Exception is the Tolånga type melaphyre with stable magnetization found in samples from two localities only.

In the calculations of directions and pole positions no corrections for tectonic disturbances have been made. The different sediments cut by the sampled dykes are horizontal or nearly horizontal and supposedly lying in original position. In the Precambrian areas where dykes were collected the granite-gneiss is often heavily crushed, jointed, and tectonically disturbed, apparently the dykes are post-tectonic.

Below follows a table of Carboniferous and Permian magnetic poles from Eurasia and 'stable Europe' (Europe west of the Urals and north of the Alpine front). The poles listed are calculated paleomagnetic poles for the periods, presented by different authors. Also given are virtual geomagnetic poles from rock formations in areas close to Scania which are of interest for this study. The same poles are plotted in fig. 33.

Table 5: Carboniferous and Permian paleomagnetic data for Europe and Eurasia

Formation, area	age	N	pole position	reference
1. Eurasia	C	24	30°N 151°E	Irving 1964
2. Eurasia	Cu	8	39°N 157°E	Creer 1970
3. Stable Europe	C	25	36°N 170°E	Philips et al. 1972
4. Eurasia	P	17	43°N 166°E	Irving 1964
5. Eurasia	P	14	41°N 163°E	Creer 1970
6. Stable Europe	P	25	43°N 163°E	Philips et al. 1972
7. Oslo igneous rocks	Pl		47°N 157°E	van Everdingen 1960
8. Ny-Hellesund - diabase Kristian- sand, Norway	Cu-Pl		39°N 160°E	Halvorsen 1970
9. Exeter lavas England	Pl		46°N 165°E	Cornwell 1967
10. Krakow volcanics Poland	Pl		43°N 165°E	Birkenmaier and Nairn 1964
11. Black Forest Germany	P		49°N 175°E	Konrad and Nairn 1972
12. Dolerite sills E Västergötland Sweden	Cu		31°N 174°E	Mulder 1971
13. Dolerite sills W Västergötland Sweden	Cu		38°N 166°E	" "
14. Dolerite dykes Scania	Cu		37°N 174°E	" "
15. Quartz dolerites Scania			39°N 172°E	This paper
16. Tolånga melaphy- res, Scania			57.5°N 165°W	" "
17. Fruålid melaphy- res, Scania			22.5°N 162°E	" "
18. Torpa Klint basic dykes, Scania			52°N 167°E	" "

N = number of rock formations used in calculation of paleo-magnetic pole.

Abbreviations used: Carboniferous C, Permian P, lower l, upper u.

The quartz dolerite pole position coincides with those previously reported by Mulder (1971) from Scania and Västergötland. It also agrees with pole positions calculated from rocks of Upper Carboniferous and Lower Permian age from Eurasia (table 5, fig. 33). Paleomagnetic poles are fairly well confirmed for that period. Irving (1964, p 119) in his summary of paleomagnetic data, concludes that during the Carboniferous the Earth's field changed considerably relative to Europe and northern Asia but became stabilized in the uppermost Carboniferous and remained little changed until late Permian. This is in agreement with later data (Storetvedt 1968, Creer 1970).

The magnetic pole positions of the different melaphyres, except Frualid, are in higher latitudes than the quartz dolerite pole, which could imply a somewhat younger age for the former. This assumption has to be tested by further radiometric age determinations. There is rather good agreement between the mean Upper Carboniferous - Lower Permian paleomagnetic poles and the pole calculated from Torpa Klint basic dyke data.

Basalts

The basalts can be divided into two groups, one with normal polarity, six sites, one with reversed polarity, four sites. One occurrence, Juskushall, is omitted from calculations due to magnetic instability. The Längenåbbe occurrence is also omitted and discussed separately. The magnetic directions with corresponding poles are listed in table 3 and plotted in fig. 32 and 34. In table 6 Mesozoic paleomagnetic poles are listed for stable Europe and Eurasia.

Table 6: Triassic, Jurassic, Cretaceous paleomagnetic data
for Europe and Eurasia

Formation, area	age	N	pole position	reference
1. Eurasia	Tr	19	50°N 146°E	Irving 1964
2. Stable Europe	Tr	7	52°N 144°E	Creer 1970
3. Stable Europe	Tr	4	46°N 141°E	Roy 1972
4. Stable Europe	Tr	8	51°N 144°E	Philips et al.1972
5. Eurasia	J	4	58°N 105°E	Irving 1964
6. Stable Europe	J	6	65°N 147°E	Philips et al.1972
7. Eurasia	Cr	3	72°N 168°E	Irving 1964
8. Stable Europe	Cr	4	71°N 178°E	Philips et al.1972
9. Basalt Scania normal polarity			60.5°N 118°E	This paper
10. Basalt Scania reversed polarity			54°N 76°E	" "
11. Basalt Scania combined			59.5°N 101°E	" "
12. Höör sandstone			76°N 170°E	" "

N = number of rock formations used in calculation of paleomagnetic pole.

Abbreviations used. Triassic Tr, Jurassic J, Cretaceous Cr.

The Triassic data in table 6 are based on a substantial number of reliable data and there is good agreement between compilations made by different authors. Irving's (1964) data for the Jurassic are based on results from sediments in England, the Alps, and Turkmenia. Philips et al. used data from volcanics in Spitzbergen and the Pyrenées together with data from European Russia, rock formations not given. Irving's Cretaceous pole is based on results from sedimentary rocks in England and Turkmenia. Philips et al. have used East European data. As a whole the collected Jurassic and Cretaceous paleomagnetic data for Europe are few and scattered and it is difficult to establish reliable paleomagnetic poles for those periods. For this study it is noteworthy that the combined basaltic Scanian

pole coincides well with Irving's Jurassic pole.

The between site scatter is rather large, specially for the reversed group. This is difficult to explain but it is probable that a larger number of sampled and measured sites would improve the reliability of the results. There are no contacts found between the basalts and the country rock which means that no tectonic observations and corrections have been made. This is an area where late fault movements could have occurred, so the possibility of post-eruptive dislocations of the basalts can not be excluded.

McElhinny (1971) reports that during 75 percent of the Mesozoic the Earth's magnetic field had normal polarity. An example of a Jurassic reversal of interest during this era is mentioned by Beck (1972) from the Dufek Intrusion in Antarctica. This rock unit is K/Ar dated to 168 ± 5 m.y. which can be compared with the reversed basalt occurrence Göbnehall dated by Klingspor to 163 m.y. No correlation has been found between the different eruption periods mentioned by Printzlau and Larsen (1972) and the two groups of polarity.

The Längenåbbe occurrence, which is K/Ar dated to about 120 m.y. (Printzlau, pers.comm.), has a magnetic direction that deviates from that of the basalts. Its mean direction is closer to the average direction of the quartz dolerites. It is plotted in fig. 27. Further, both in the field and under the microscope the rock is similar to the quartz dolerites. Here is a contradiction between K/Ar determinations and magnetic measurements.

Höör sandstone

This is a spot reading of the magnetic directions in the Jurassic sediments and though the data are too few to base a discussion on, it suggests that a continuation of sampling and measuring of the Mesozoic sediments in Scania would be worthwhile.

CONCLUSIONS

Quartz dolerites and melaphyres

The quartz dolerites contain a stable magnetization and their direction and stability suggest that it was acquired as TRM when the rock was formed in the existing geomagnetic field. This is in good agreement with paleomagnetic data from rock formations of the same period, Upper Carboniferous to Lower Permian, in stable Europe. Radiometric age determinations of the quartz dolerites confirm this assumption.

The melaphyres of the Tolånga type and the basic dykes in the Torpa Klint quarry have magnetic directions which in spite of the magnetic instability in these rocks, indicates that they are formed in the same period as the quartz dolerites. This is sustained by age determinations.

The Fruålid melaphyre contains a stable magnetization that deviates from that of the before mentioned rocks. This is ascribed to secondary alterations of the original magnetic minerals. This, in connection with the influences of later changes in the geomagnetic field imprinted on the secondary magnetic minerals, obscure the primary magnetic direction.

The kullaites and the syenite porphyry measured proved unstable and not suitable for paleomagnetic work.

Basalts

The paleomagnetic evidence from the Scanian basalts indicate that their stable magnetization is the original TRM. The rarity of reliable middle to upper Mesozoic paleomagnetic data for stable Europe complicates and interpretation but a comparison. with existing results (Irving, 1964) together with findings from preliminary K/Ar and microfossil dating suggest a Jurassic age for the basaltic volcanism in Central Scania.

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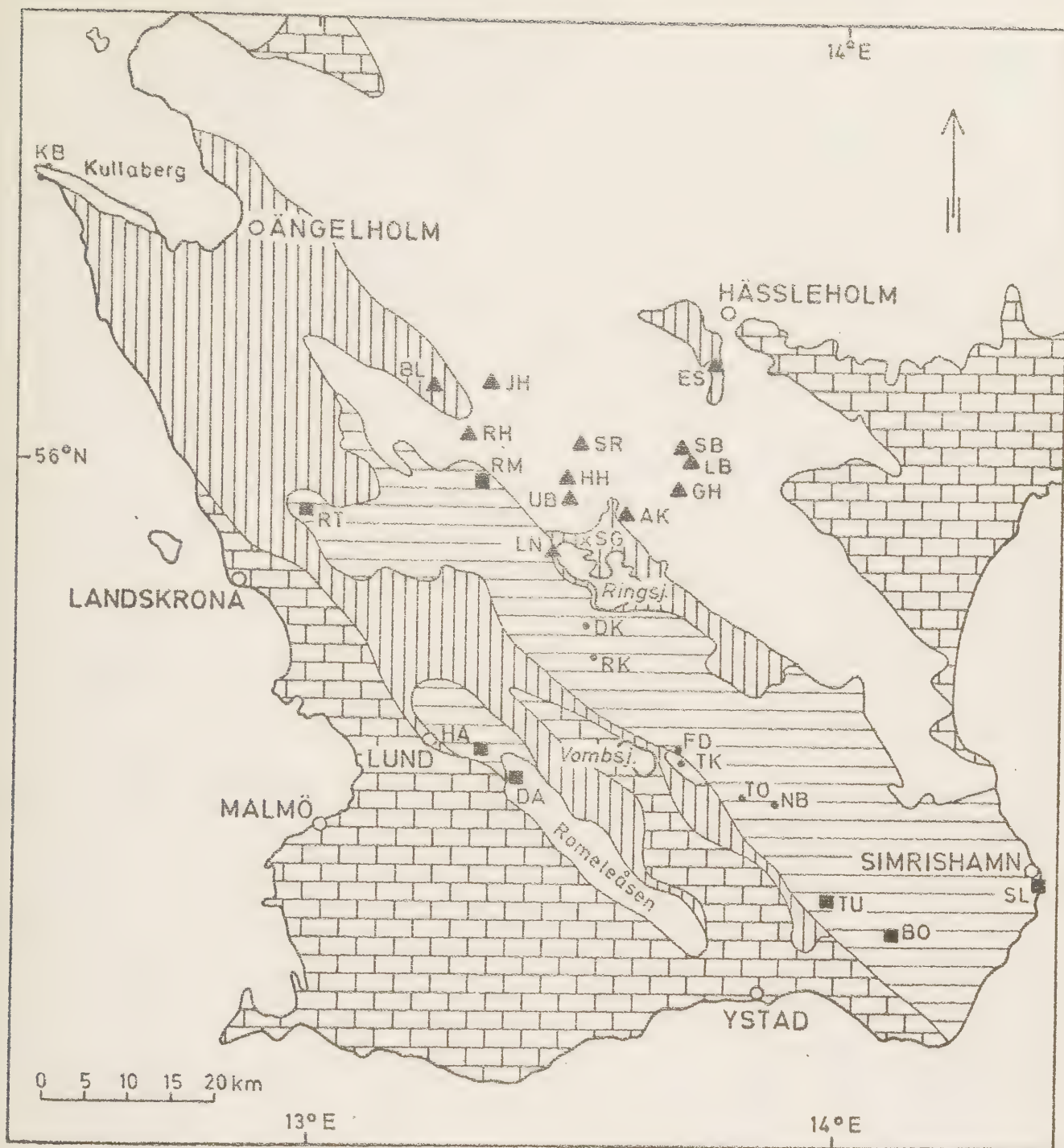
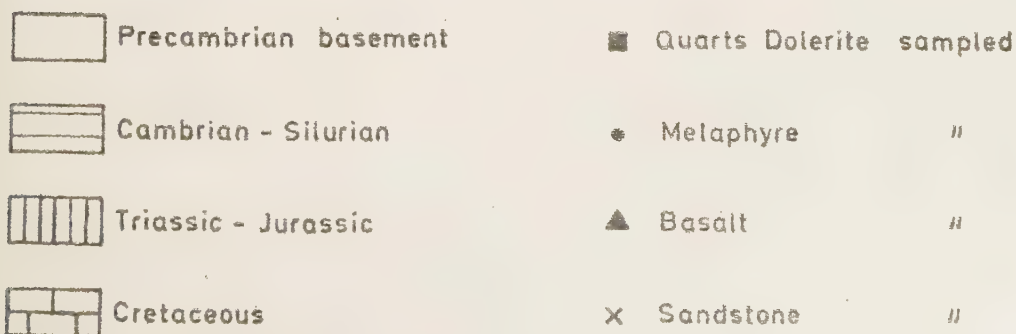


Fig.1
GEOLOGIC MAP OF SCANIA (Simplified after Stanfors and Bergström 1966)





Sketch map of the Torpa Klint Quarry

Fig.2

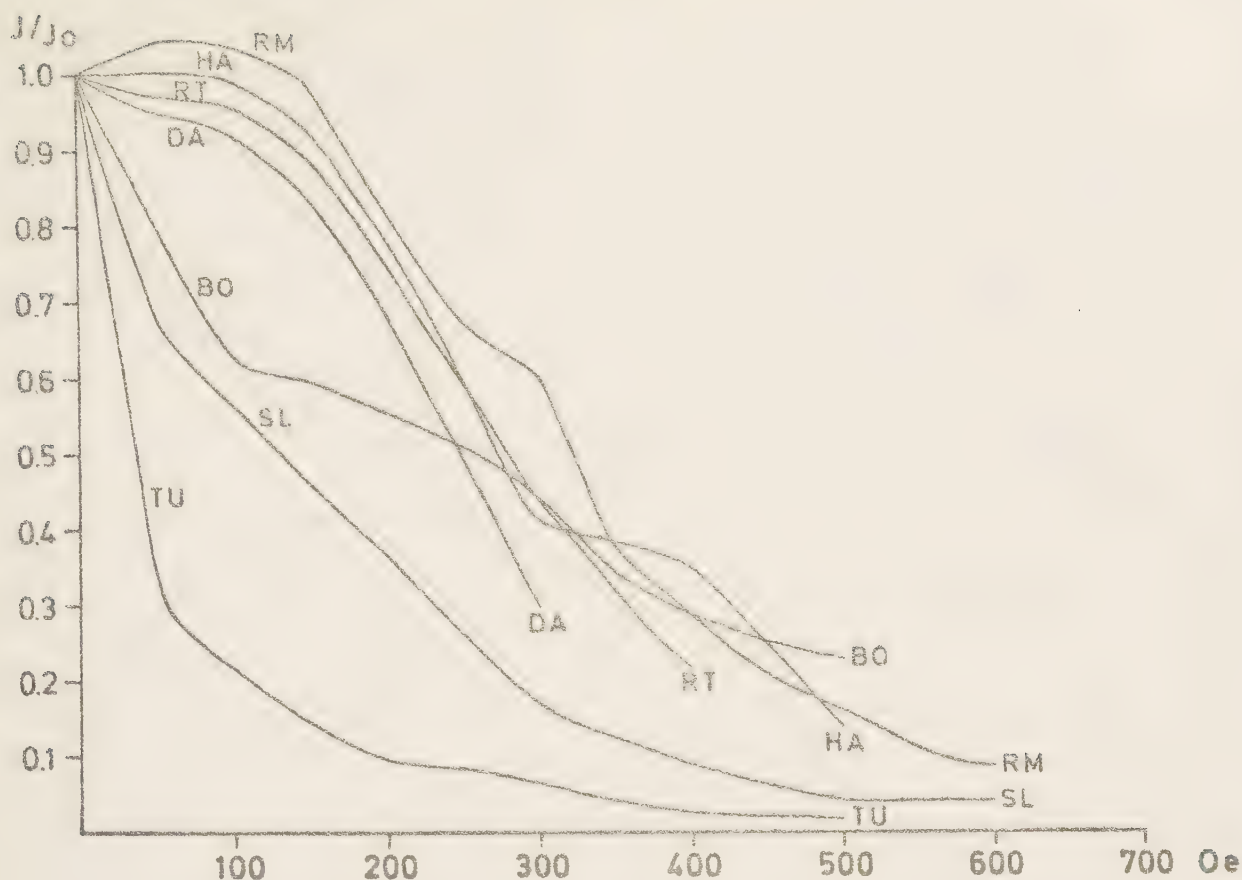


Fig. 3. Quartz dolerites, demagnetizing curves.

SL = Simrislund	HA = Hardeberga
BO = Bollerup	RM = Röstånga mölla
TU = Tomelilla-Ullstorp	RT = Rönnarp-Tågarp
DA = Dalby	

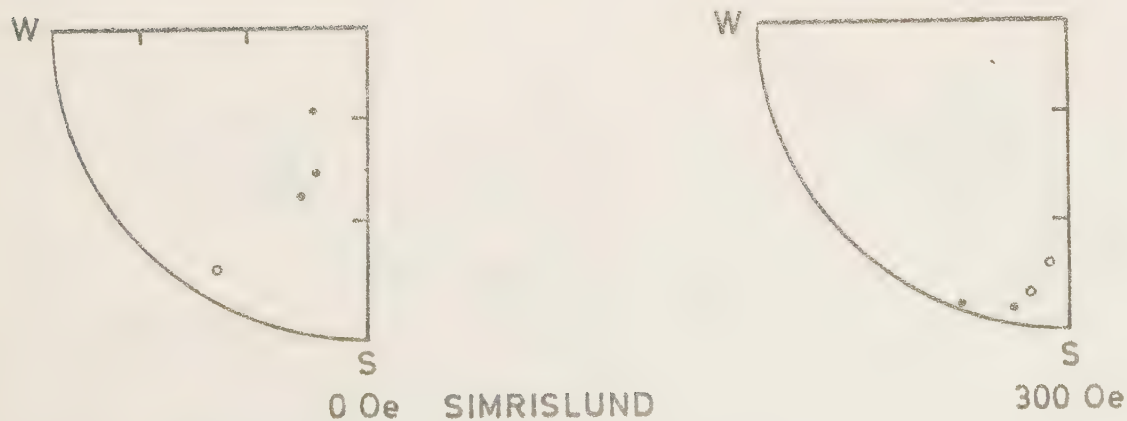
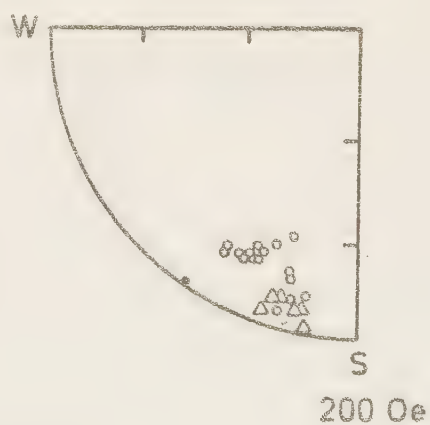
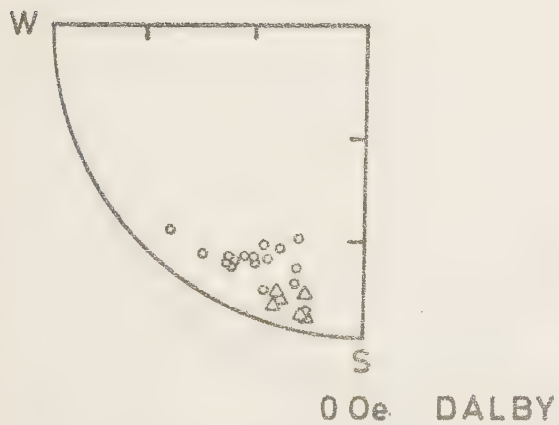
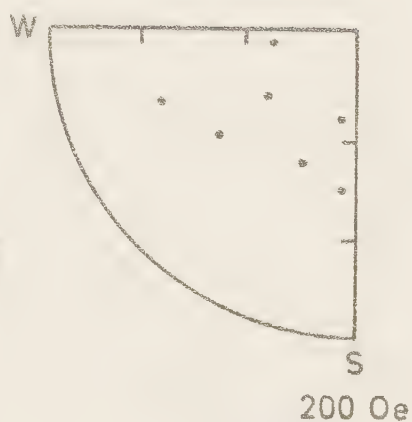
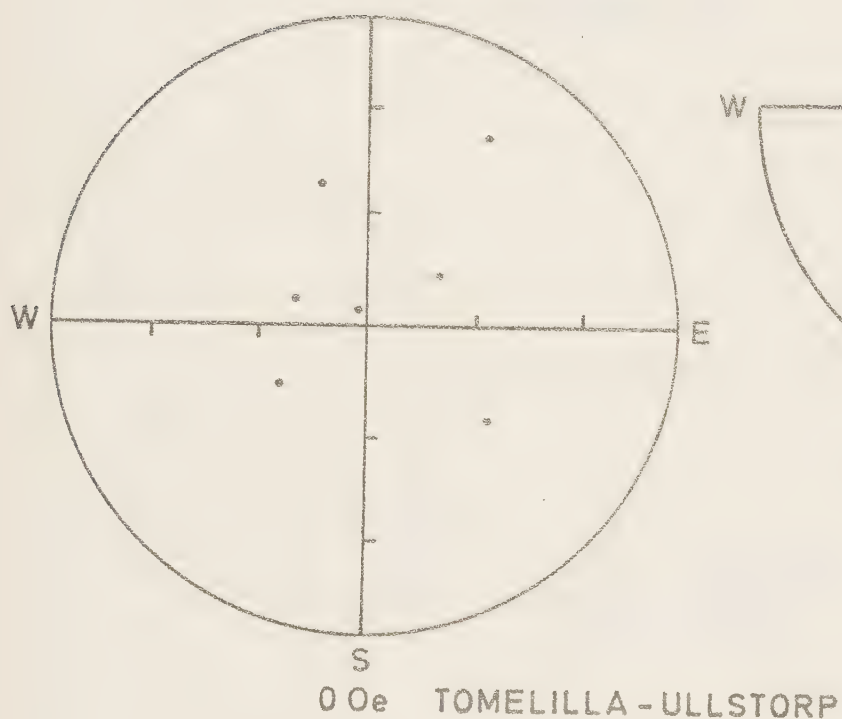
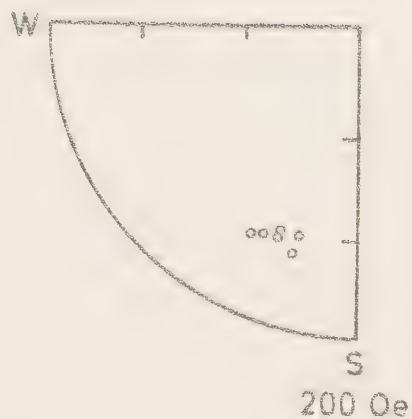
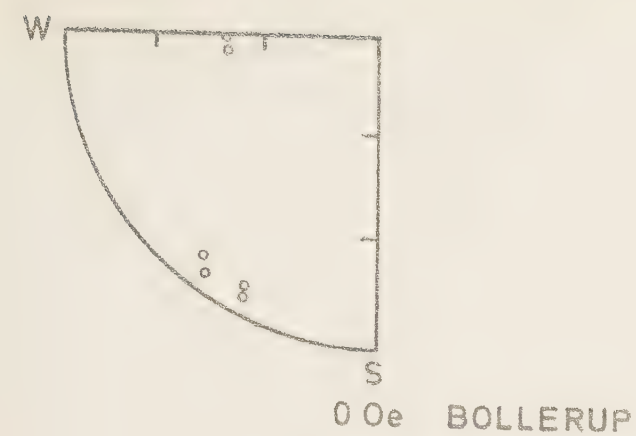
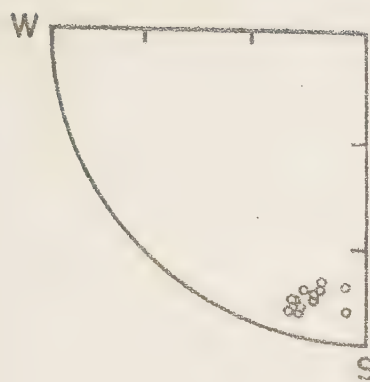


Fig. 4. Quartz dolerite, directions of remanent magnetization before (left) and after demagnetization.

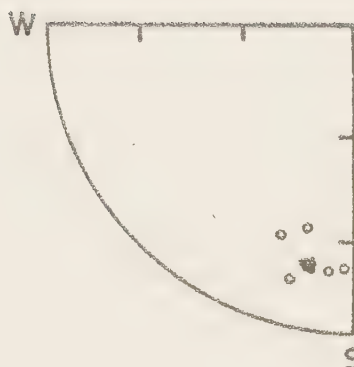


○ = DA1 △ = DA2

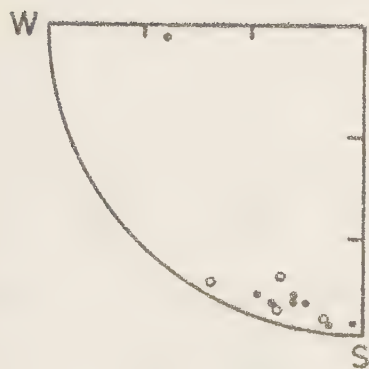
Fig. 5. Quartz dolerite, directions of remanent magnetization before (left) and after demagnetization.



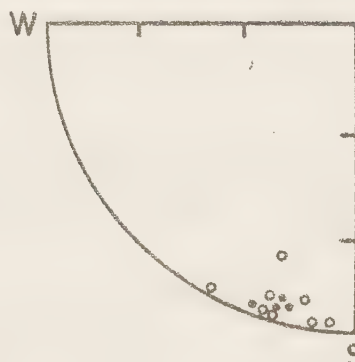
0 Oe HARDEBERGA



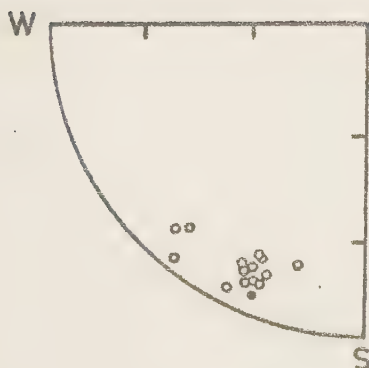
200 Oe



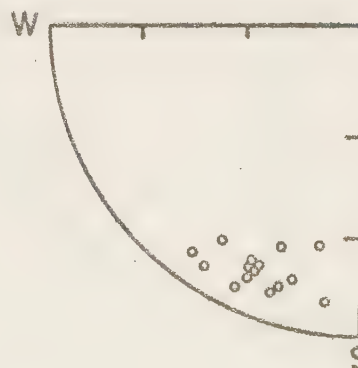
0 Oe RÖSTÅNGA MÖLLA



300 Oe



0 Oe RÖNNARP - TÅGARP



300 Oe

Fig. 6. Quartz dolerite, directions of remanent magnetization before (left) and after demagnetization.

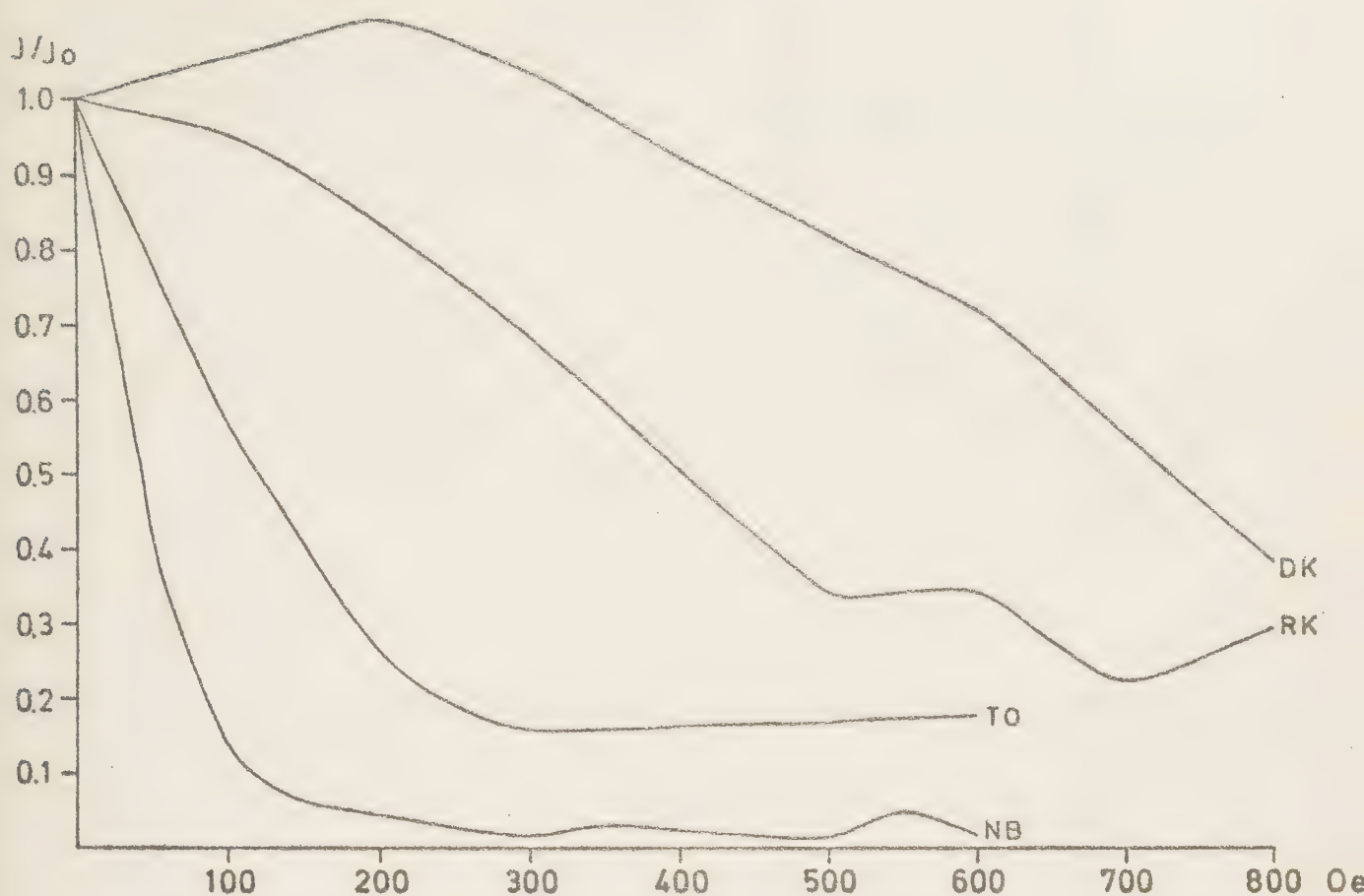


Fig. 7. Melaphyres, Tolånga type, demagnetizing curves.

NB = Näsby
TO = Tolånga

RK = Rövarekulan
DK = Drakakull

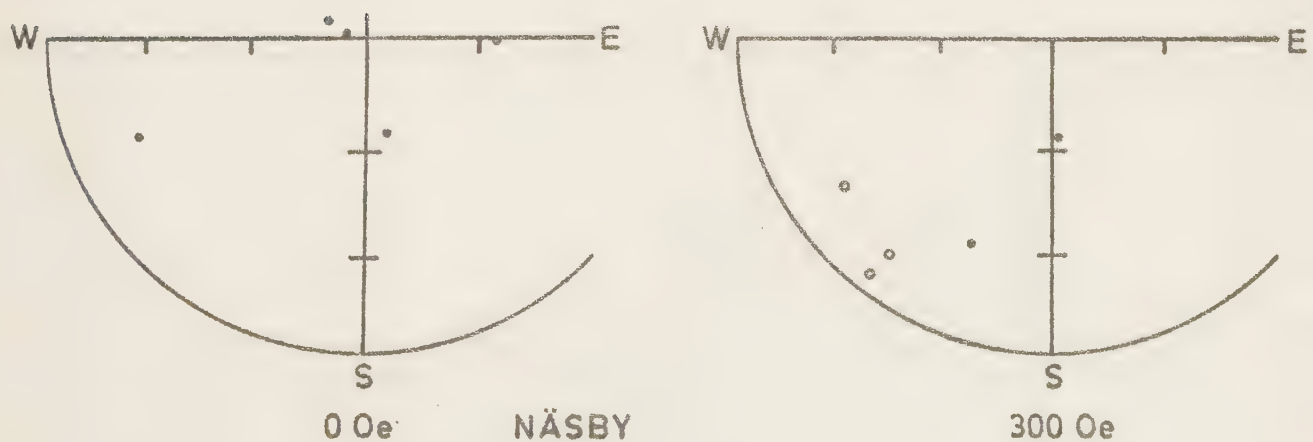


Fig. 8. Melaphyre, Tolånga type, directions of remanent magnetization before (left) and after demagnetization.

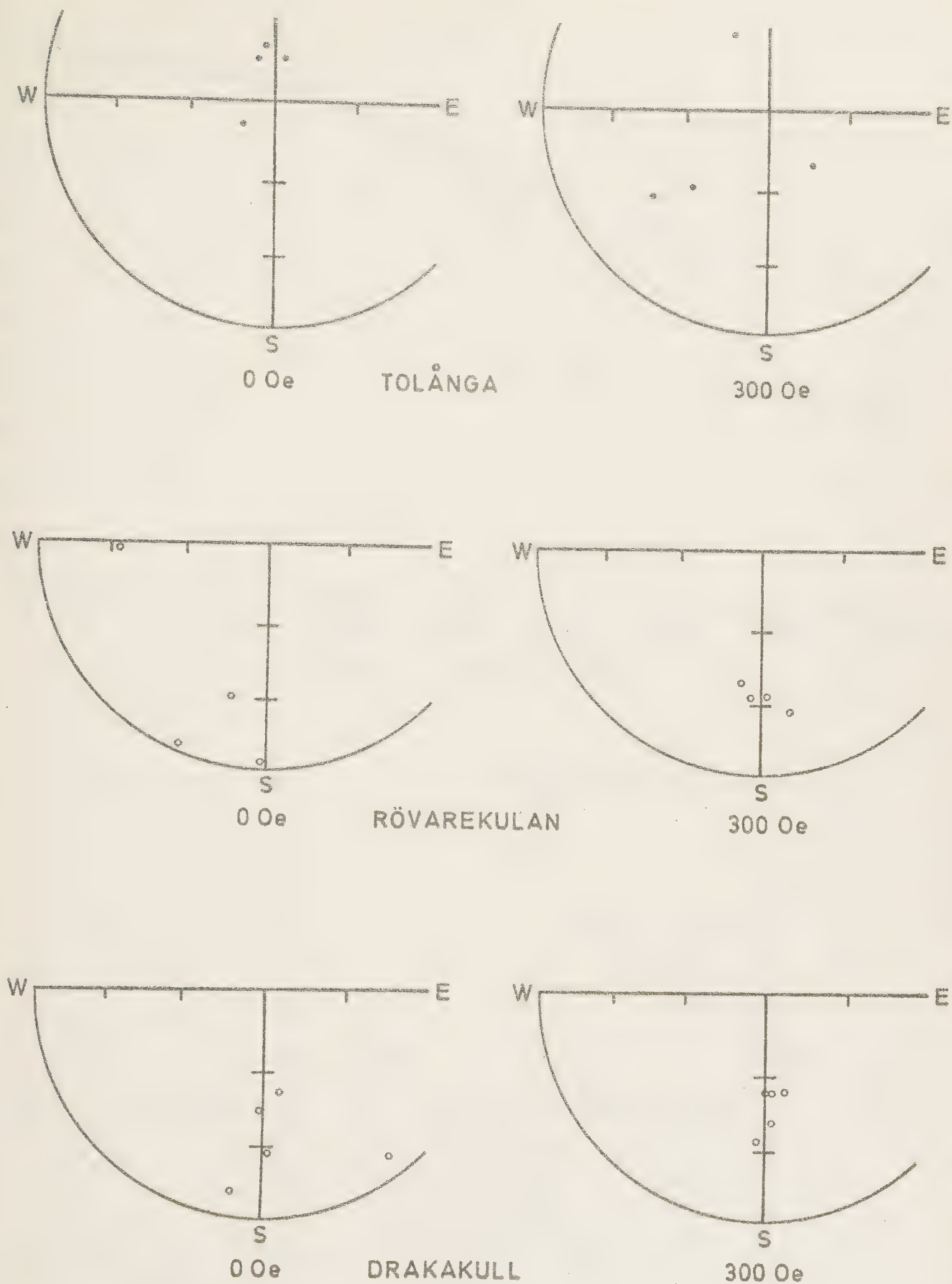


Fig. 9. Melaphyres, Tolånga type, directions of remanent magnetization before (left) and after demagnetization.

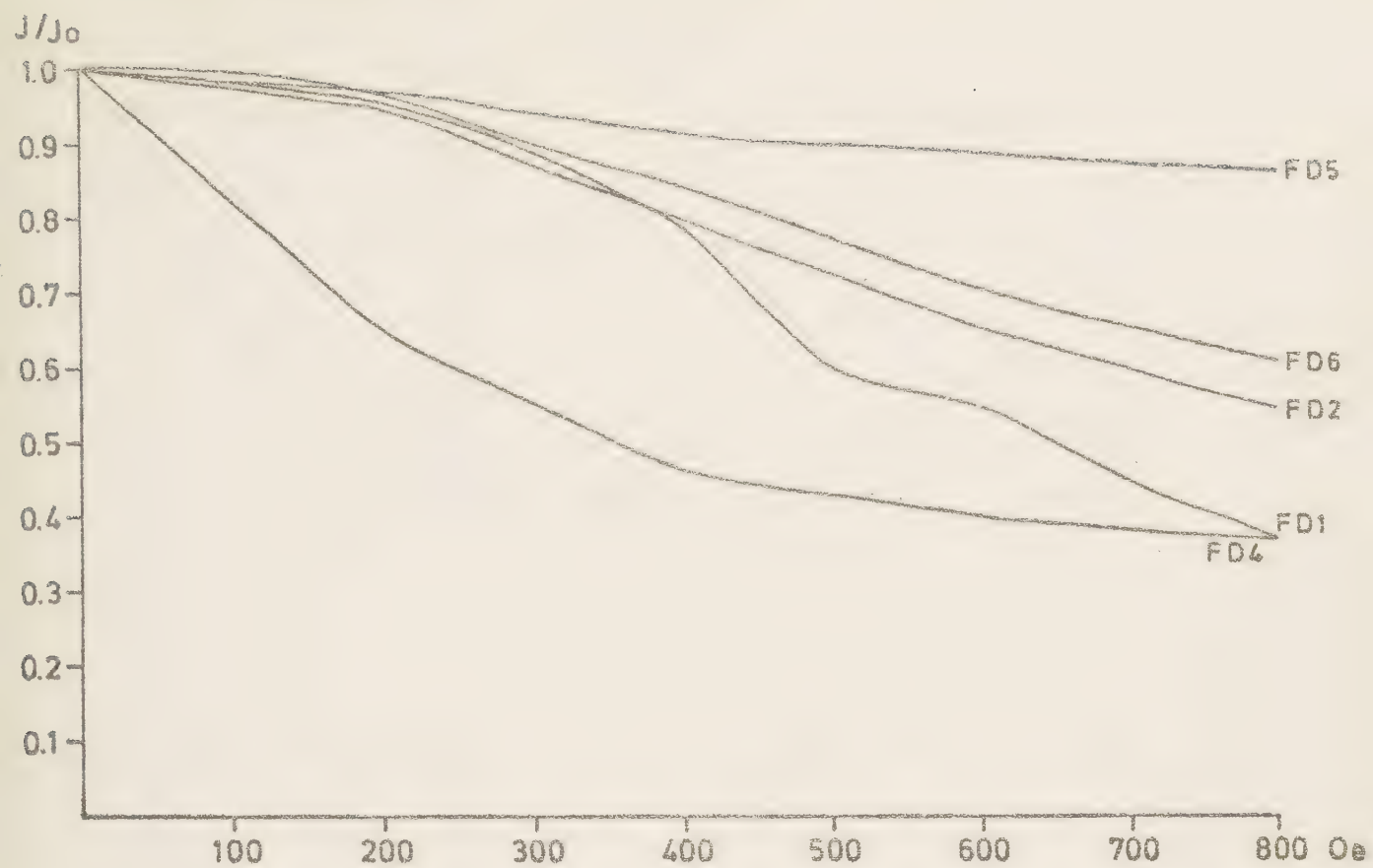


Fig. 10. Melaphyre, Frualid, demagnetizing curves.

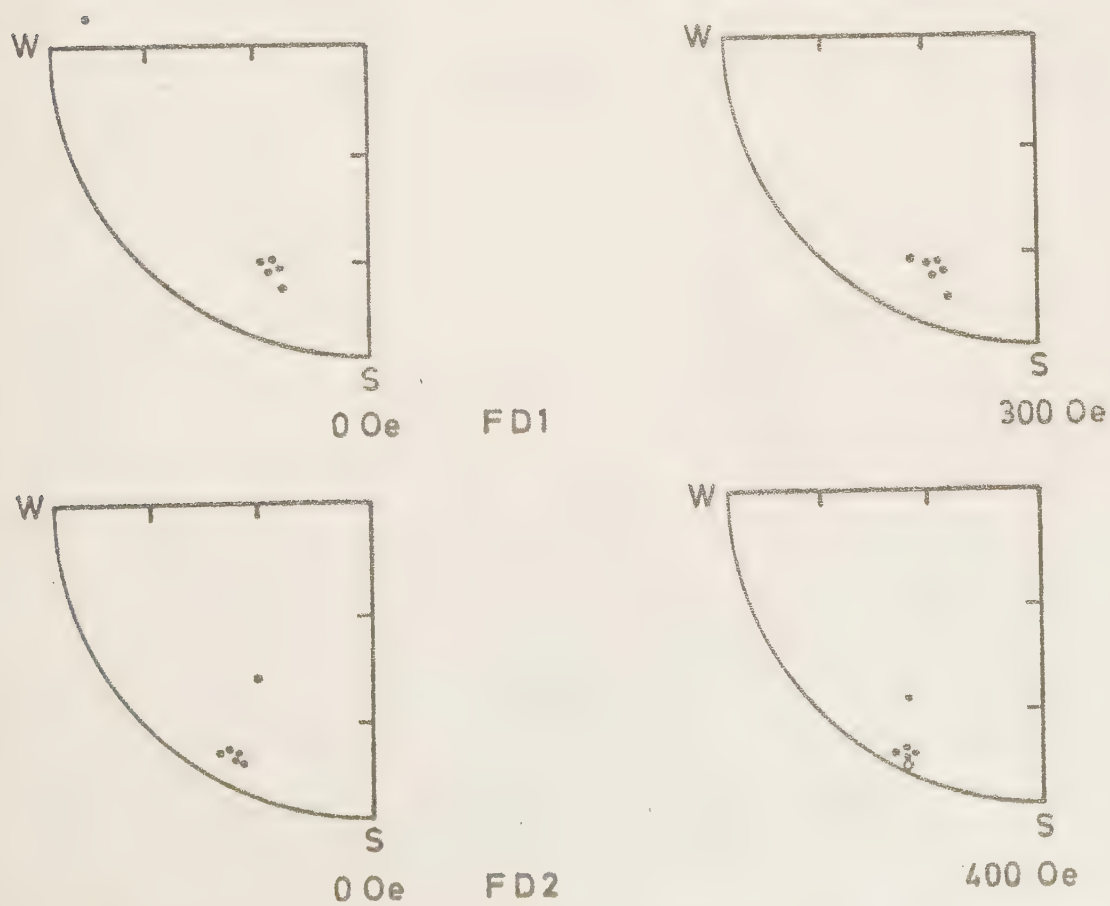


Fig. 11. Melaphyre, Frualid, directions of remanent magnetization before (left) and after demagnetization.

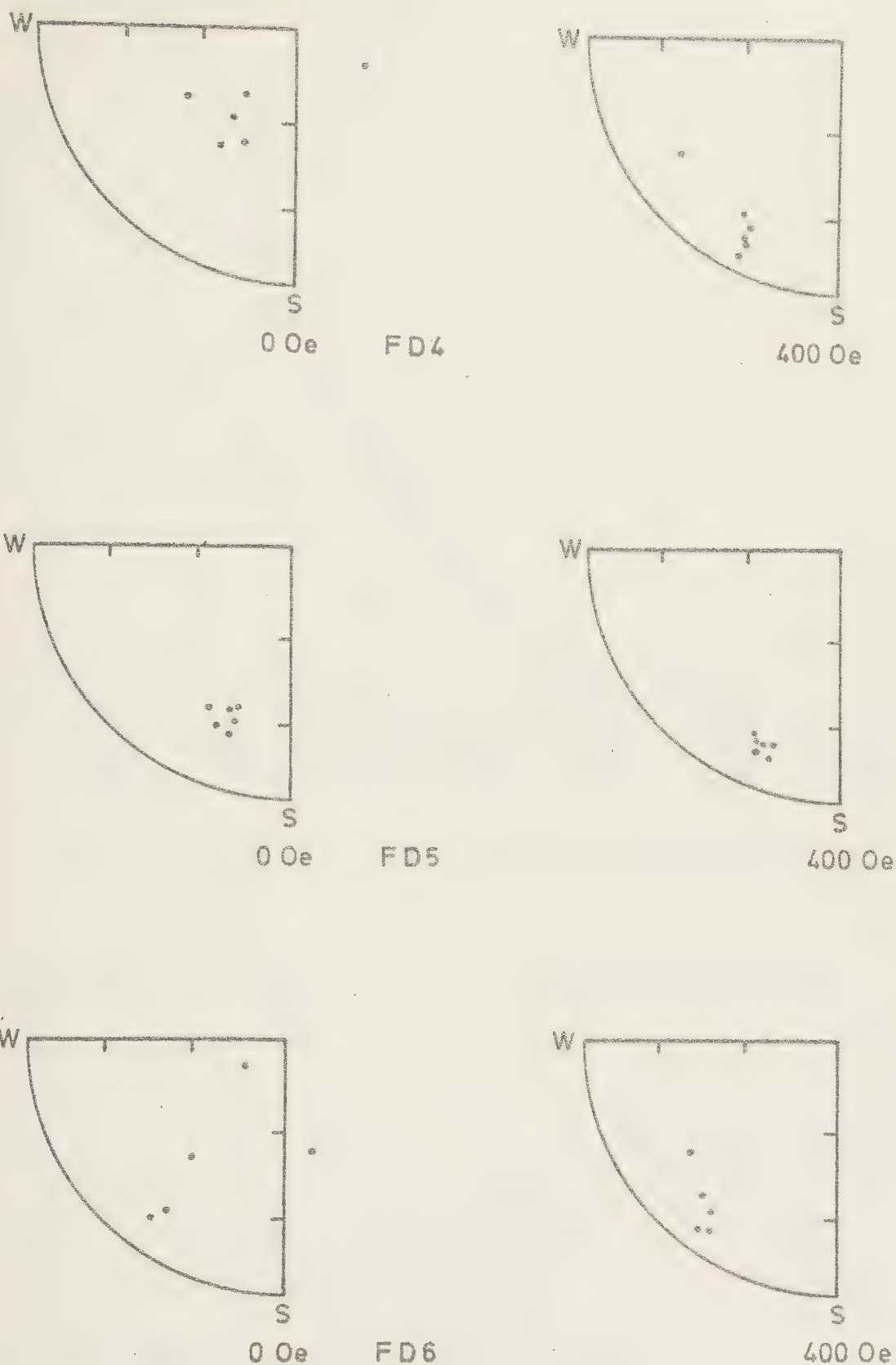


Fig. 12. Melaphyre, Frua lid, directions of remanent magnetization before (left) and after demagnetization.

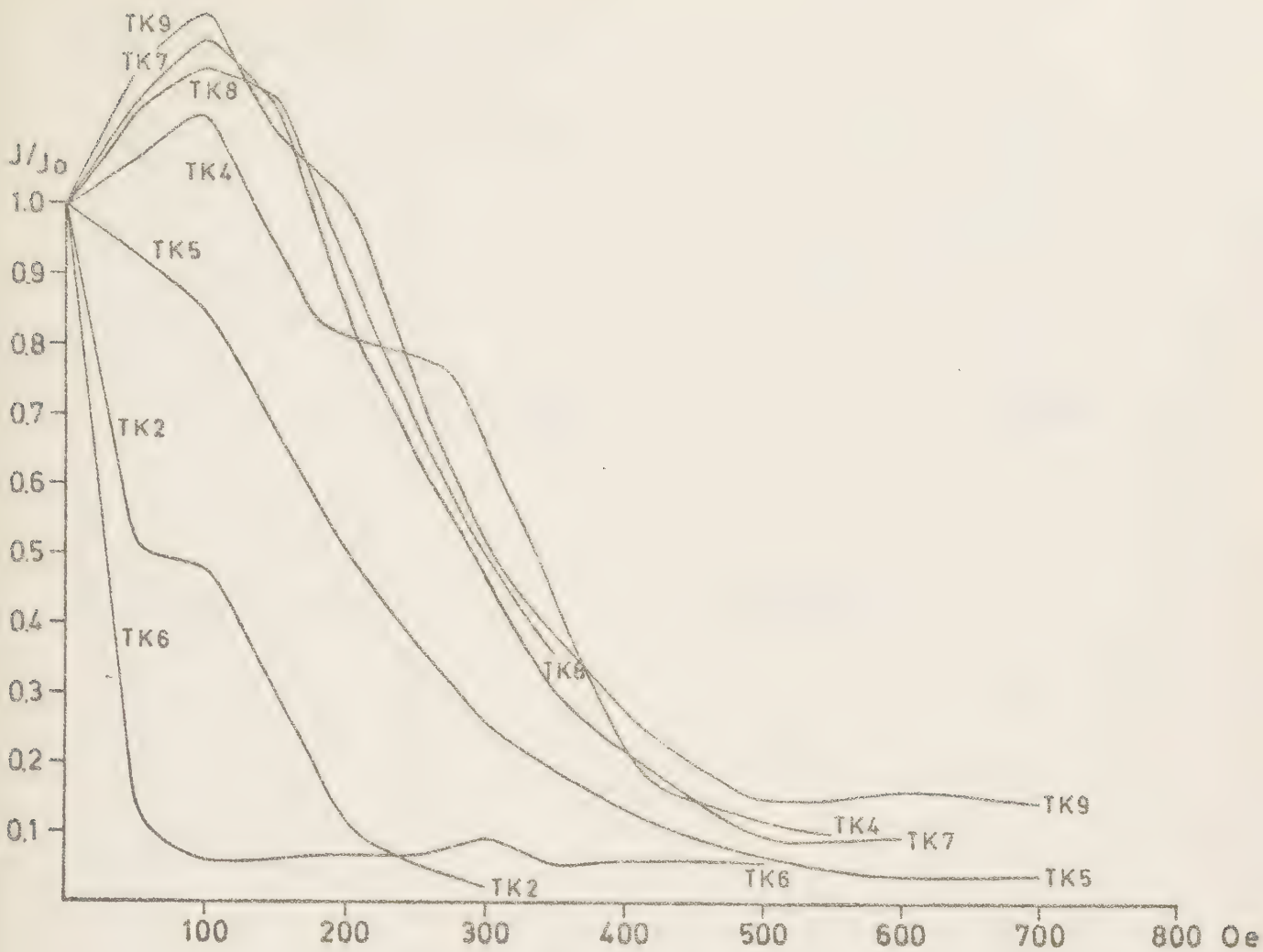


Fig. 13. Basic dykes, Torpa Klint, demagnetizing curves.

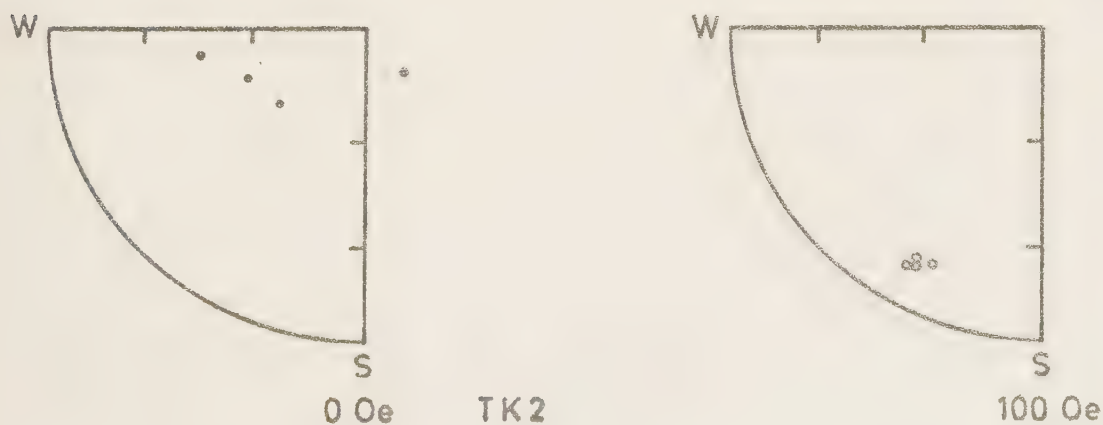


Fig. 14. Basic dykes, Torpa Klint, directions of remanent magnetization before (left) and after demagnetization.

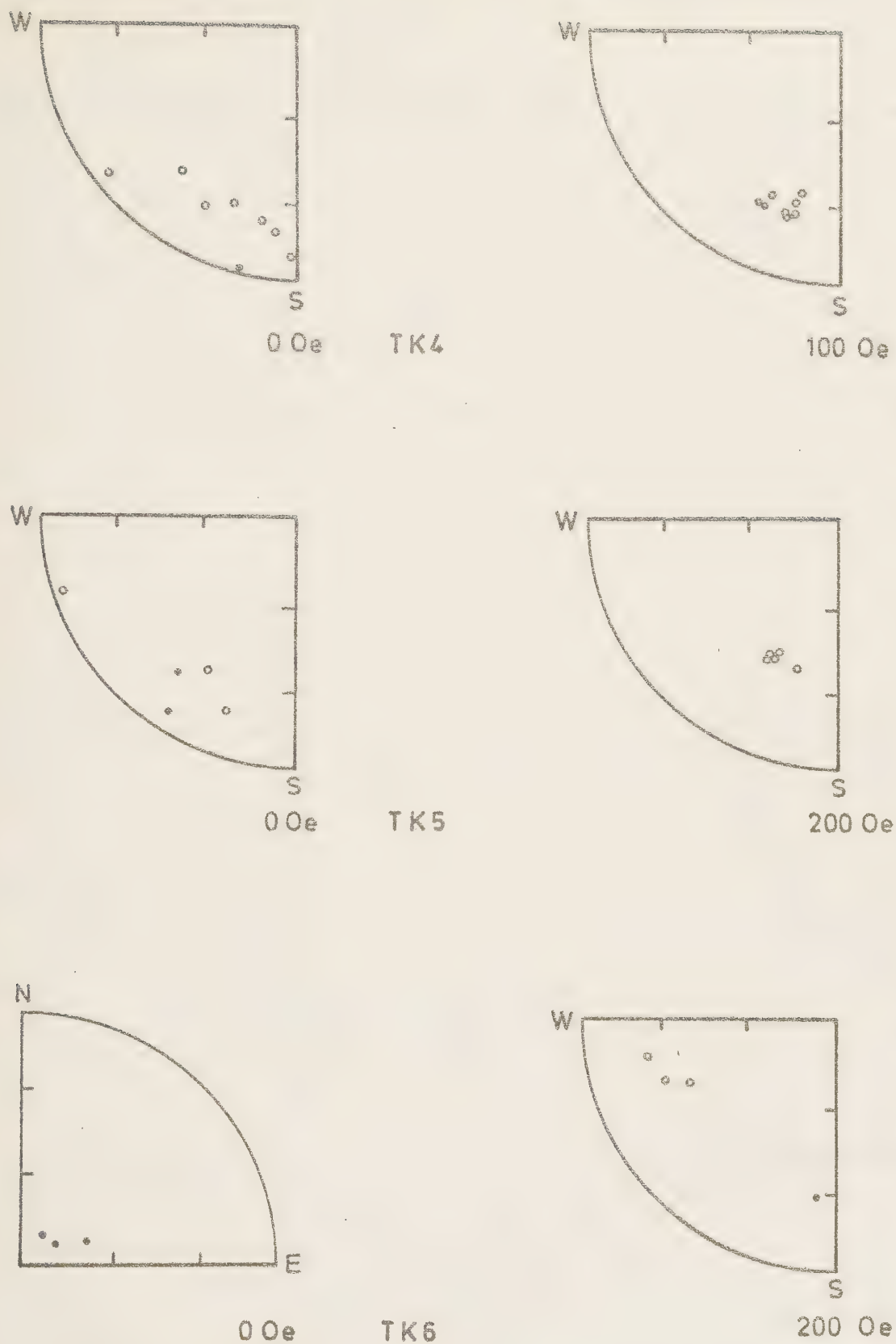


Fig. 15. Basic dykes, Torpa Klint, directions of remanent magnetization before (left) and after demagnetization.

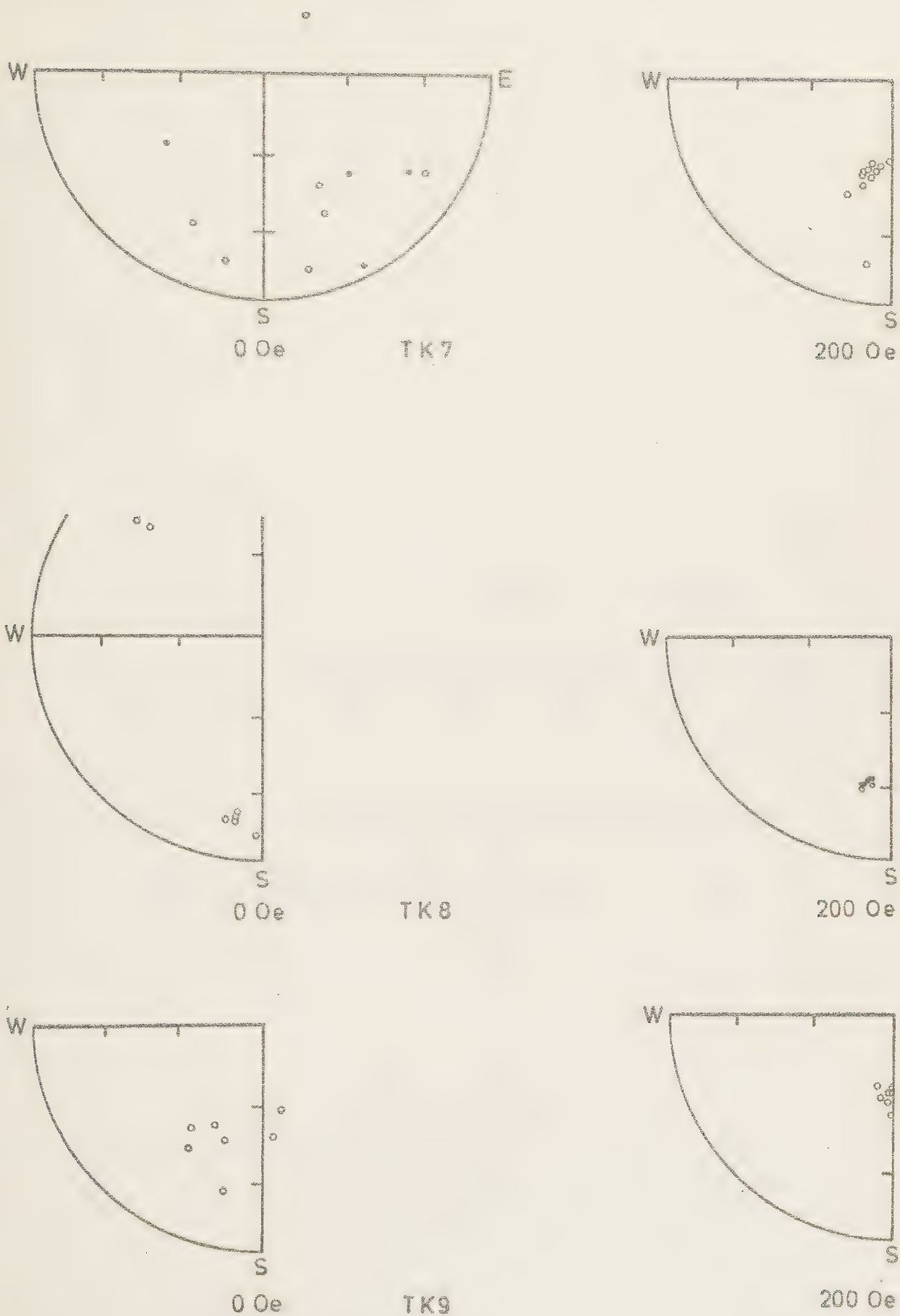


Fig. 16. Basic dykes, Torpa Klint, directions of remanent magnetization before (left) and after demagnetization.

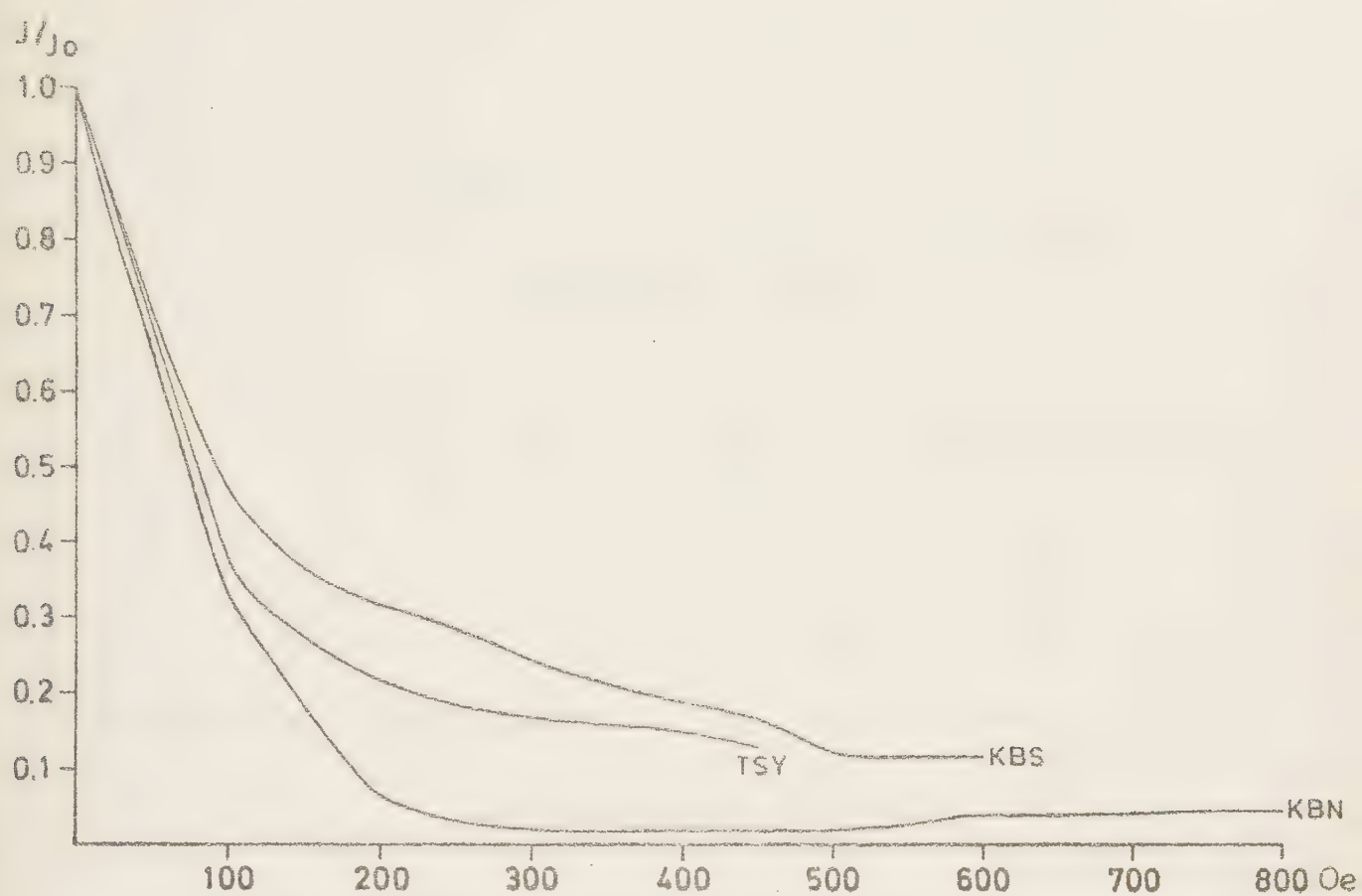
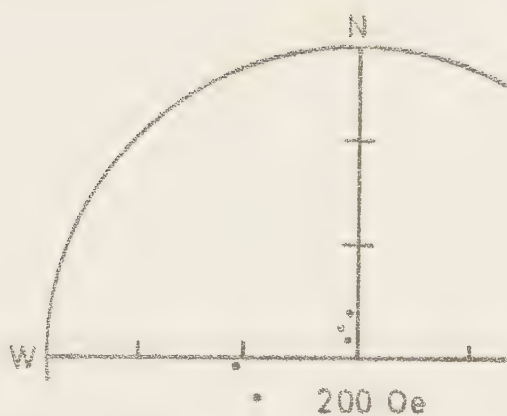
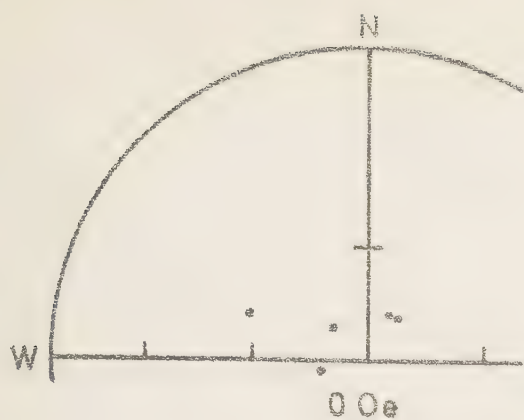


Fig. 17. Kullaites and syenite porphyry, demagnetizing curves.

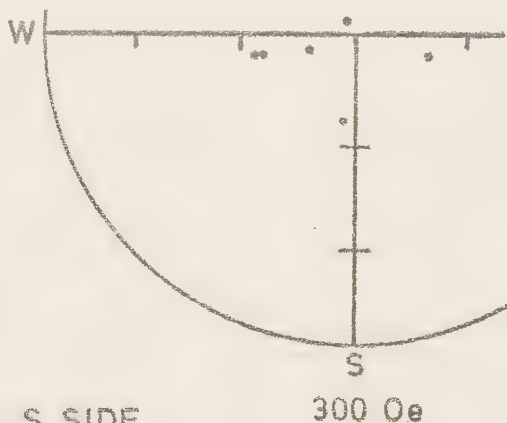
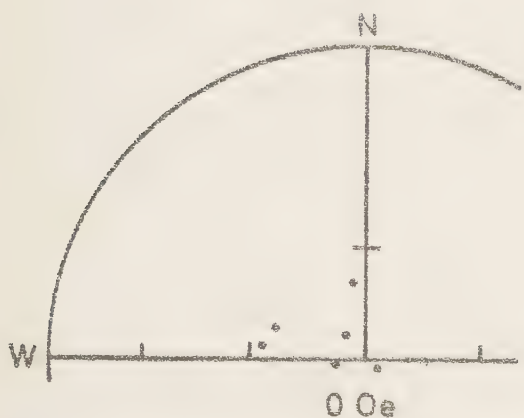
KBN = Kullaberg, northern side

KBS = Kullaberg, southern side

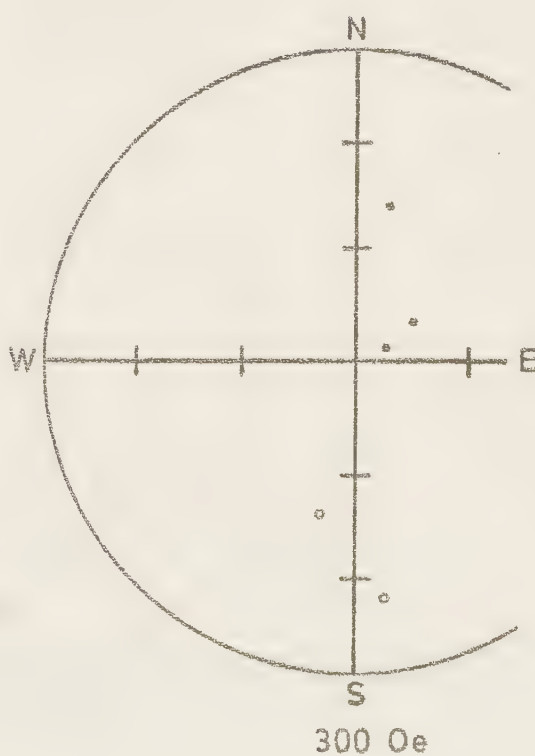
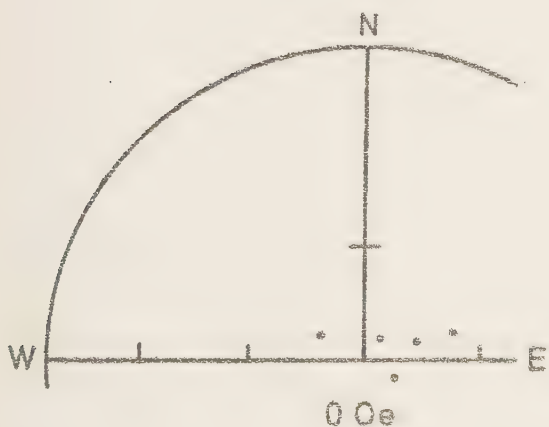
TSY = Torpa Klint, syenite porphyry



KULLABERG N. SIDE



KULLABERG S. SIDE



TORPAKLINT, SYENITE PORPHYRY

Fig. 18. Kullaites and syenite porphyry, directions of remanent magnetization before (left) and after demagnetization.

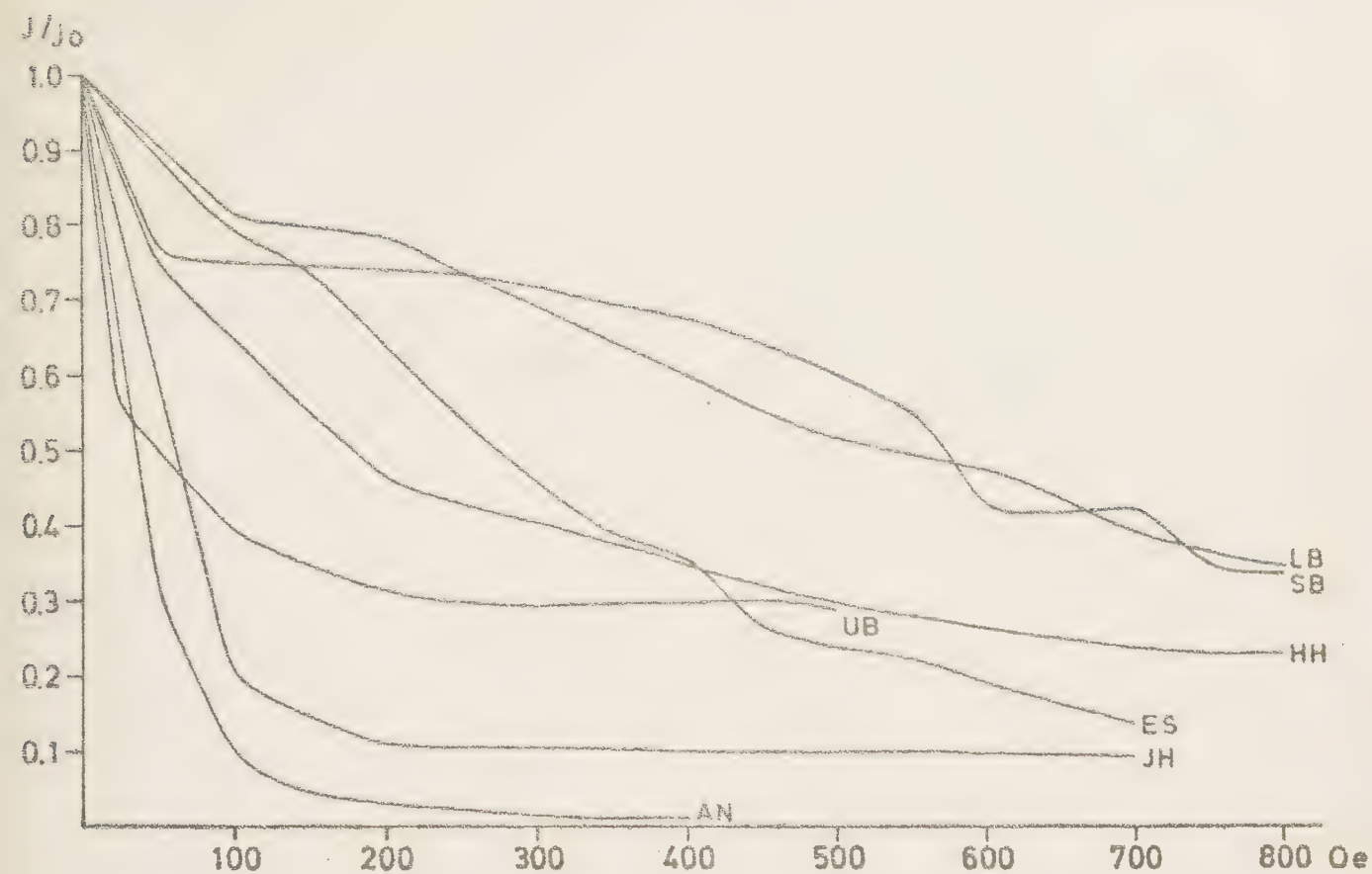


Fig. 19. Basalts, normal polarity, demagnetizing curves.

AN = Annéklev	HH = Nästhallarna
ES = Espet	UB = Ulfsberg
SB = Snababerg	JH = Juskushall
LB = Lönneberg	



Fig. 20. Basalt, directions of remanent magnetization before (left) and after demagnetization.

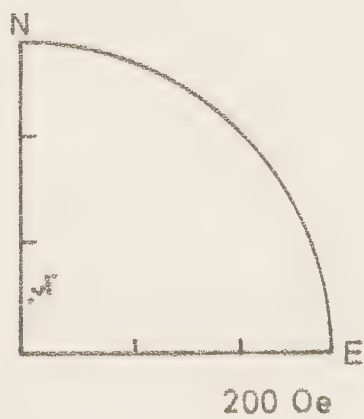
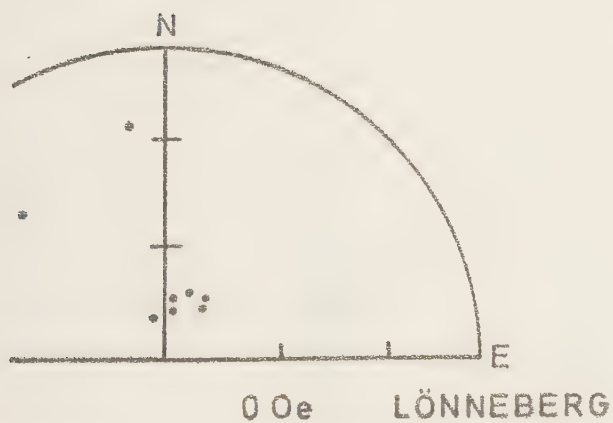
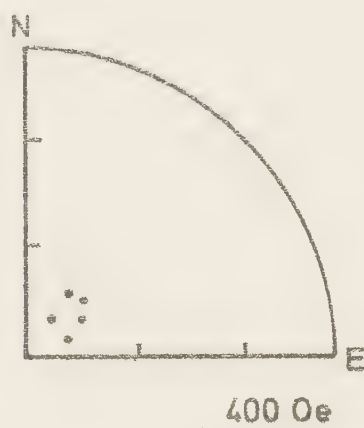
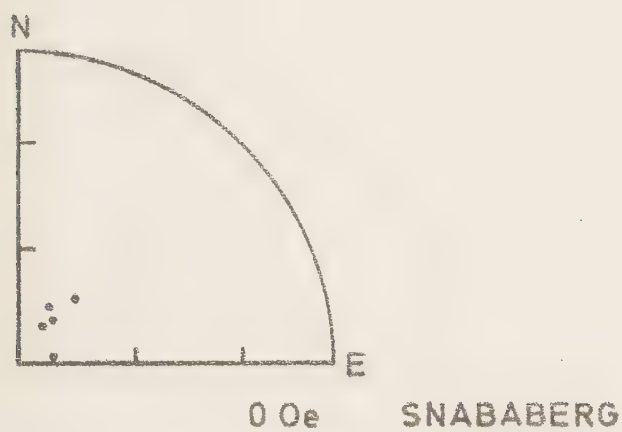
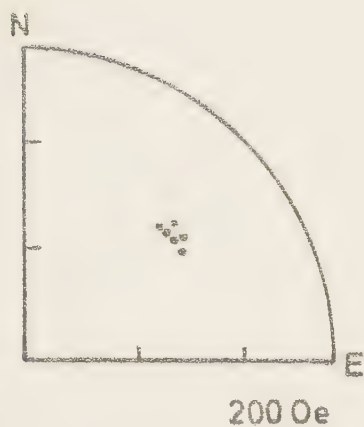
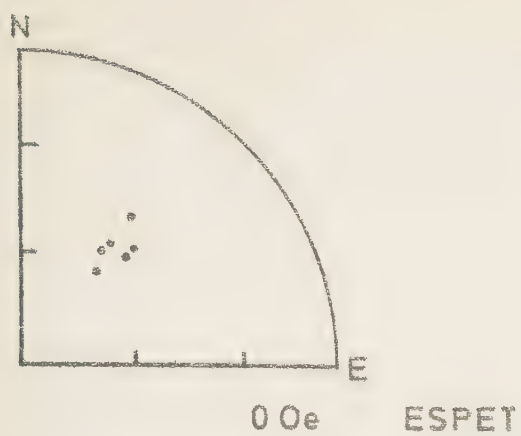
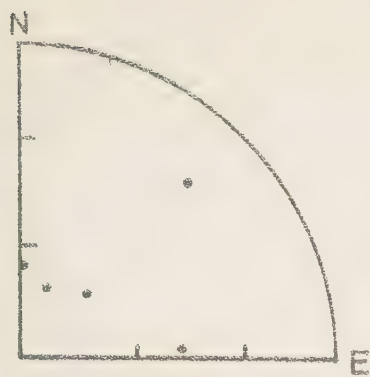
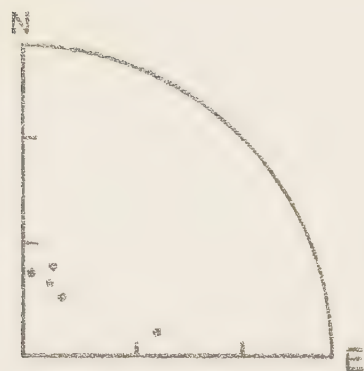


Fig. 21. Basalts, directions of remanent magnetization before (left) and after demagnetization.

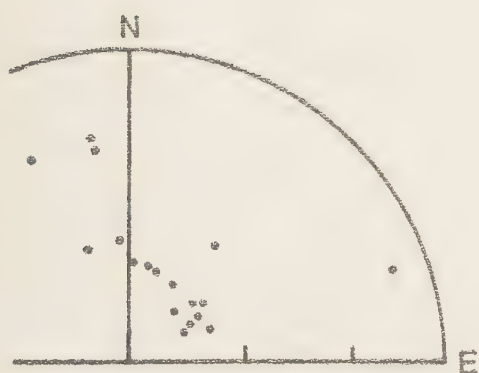


0 Oe

HÄSTHALLARNA

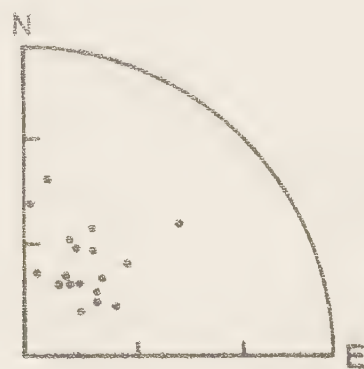


200 Oe

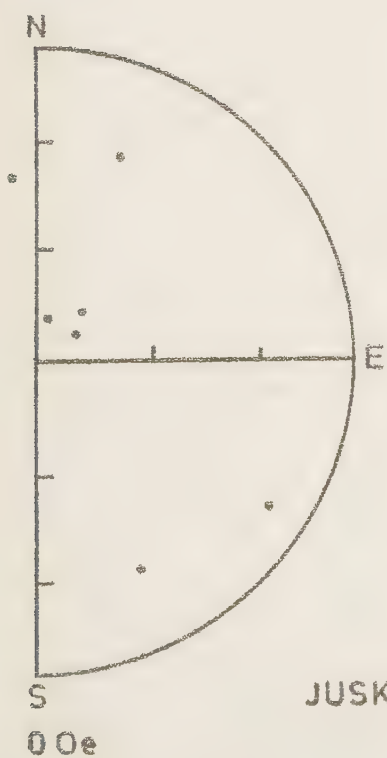


0 Oe

ULFSBERG

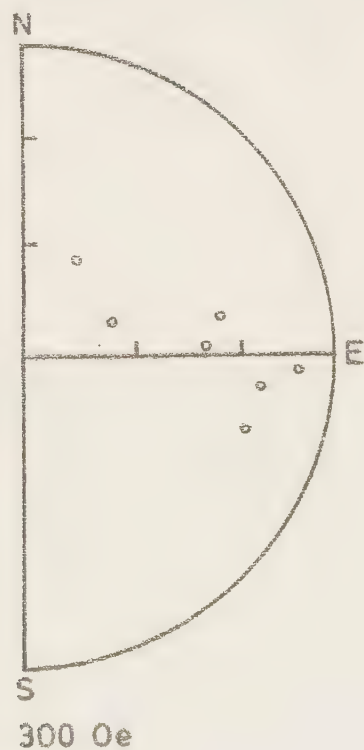


300 Oe



0 Oe

JUSKUSHALL



300 Oe

Fig. 22. Basalts, directions of remanent magnetization before (left) and after demagnetization.

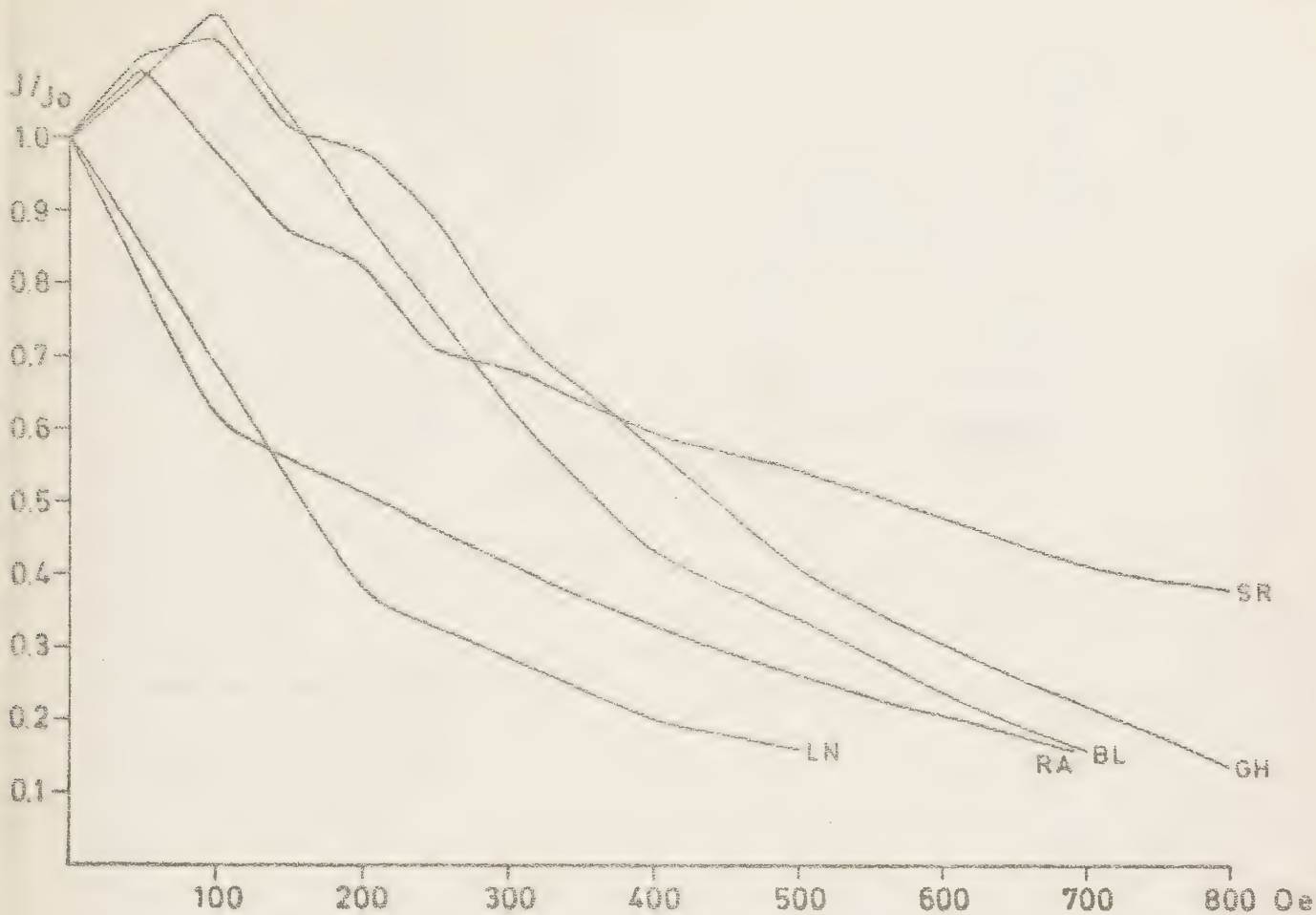


Fig. 23. Basalts, reversed polarity, demagnetizing curves.

GH = Göbnehall
 SR = Säte-N. Rörum
 BL = Bonarp-Ljungbyhed
 RA = Rallate
 LN = Längenåbbe

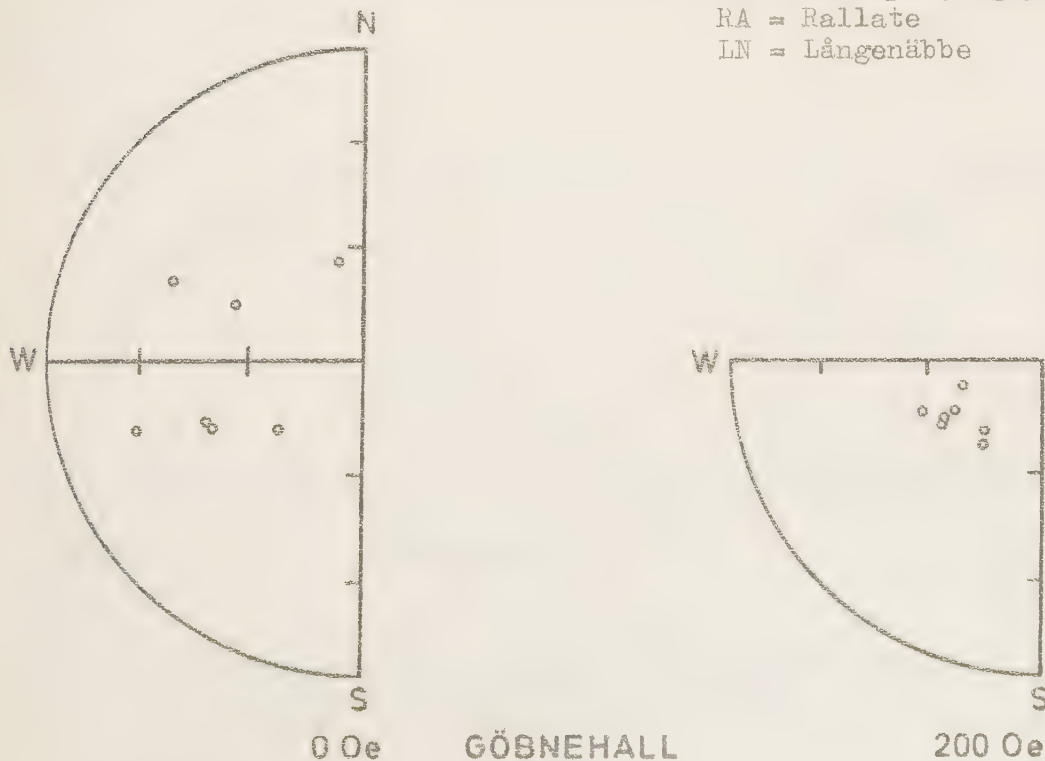
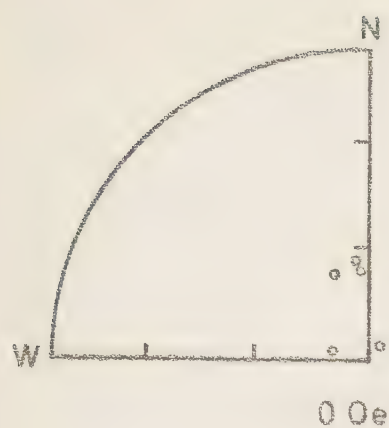
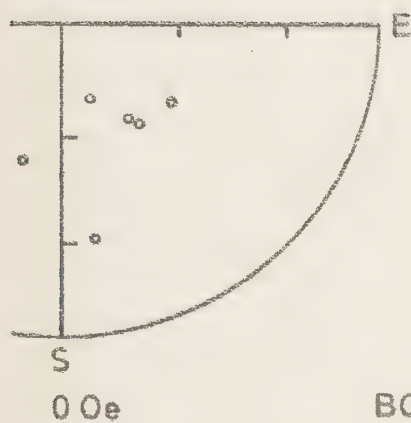
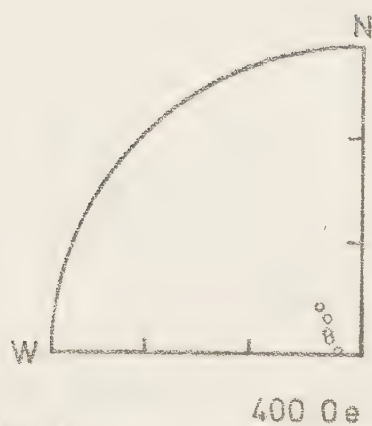


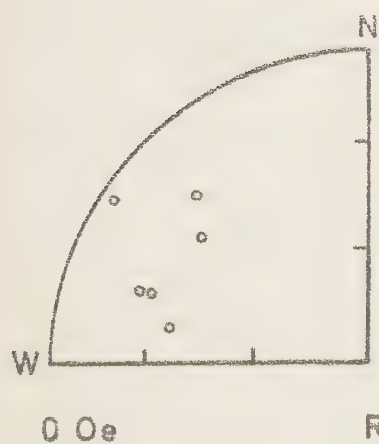
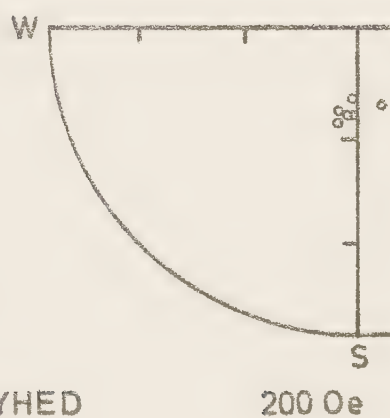
Fig. 24. Basalts, directions of remanent magnetization before (left) and after demagnetization.



SÄTE - N. RÖRUM



BONARP - LJUNGBYHED



RALLATE

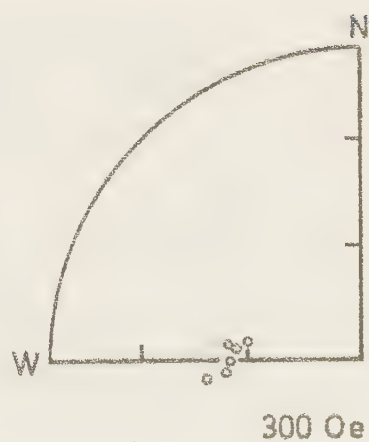


Fig. 25. Basalts, directions of remanent magnetization before (left) and after demagnetization.



Fig. 26. Basalt, directions of remanent magnetization before (left) and after demagnetization.

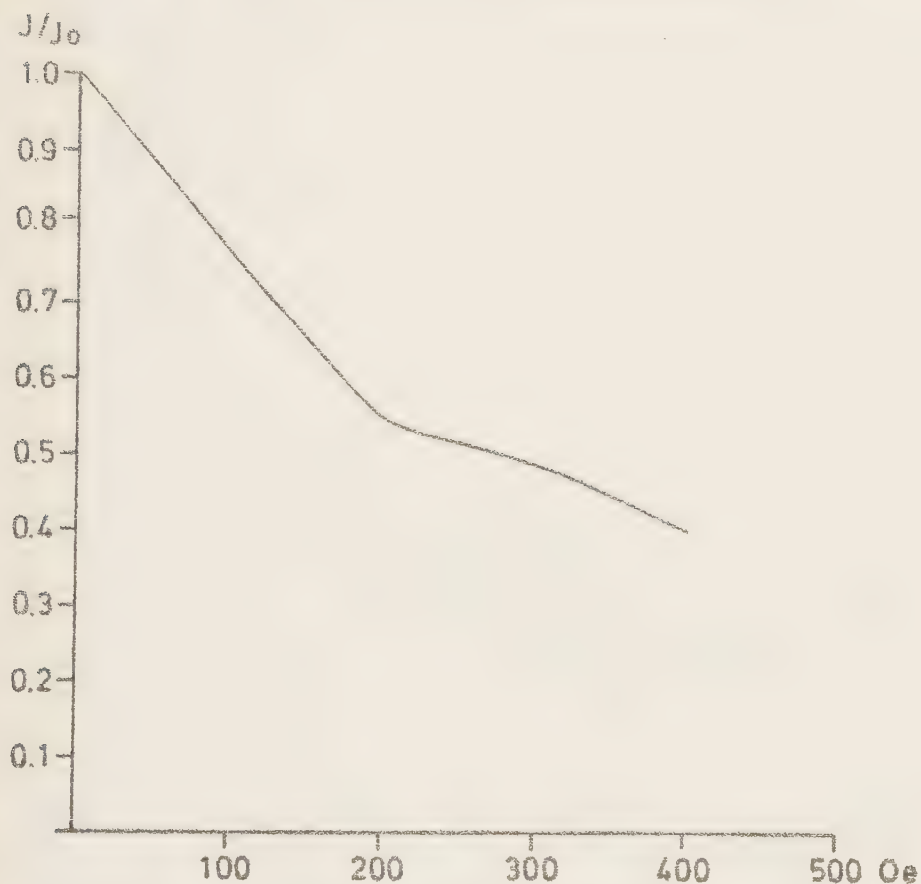


Fig. 27. Höör, sandstone, demagnetizing curve.

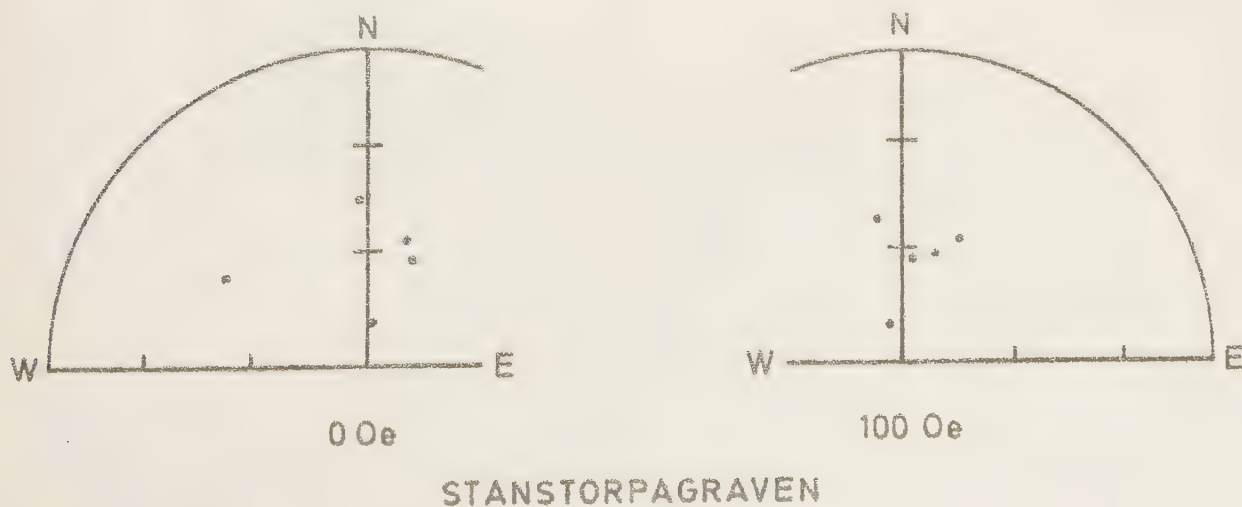


Fig. 28. Höör sandstone, directions of remanent magnetization before (left) and after demagnetization.

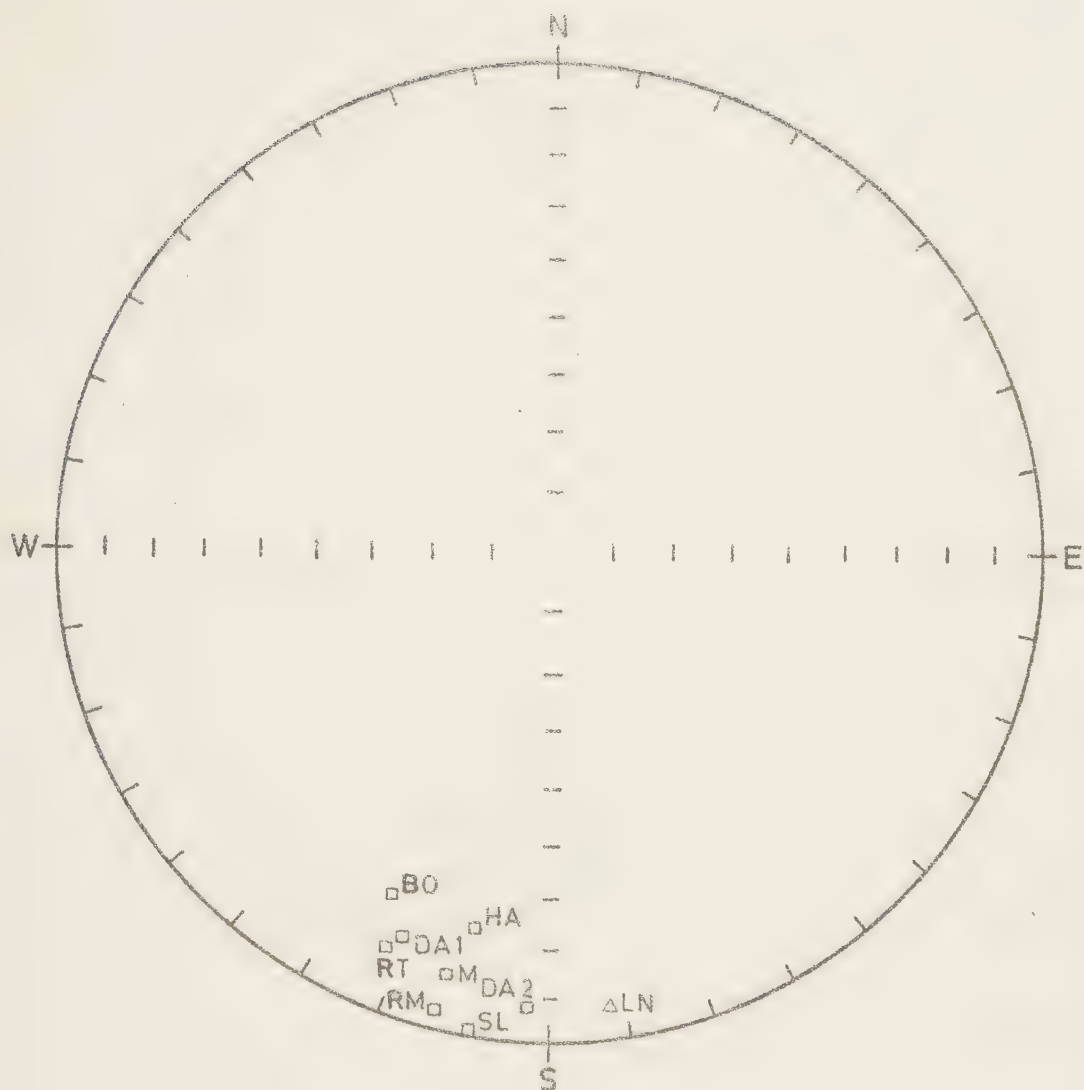


Fig. 29. Quartz dolerites, equal area stereographic projection of mean directions after demagnetization.

SL = Simrislund
 BO = Bollerup
 DA = Dalby
 HA = Hardeberga
 RM = Röstänga mölla
 RT = Rönnarp-Tågarp
 M = Mean direction
 LN = Längenäbbe ('basalt')

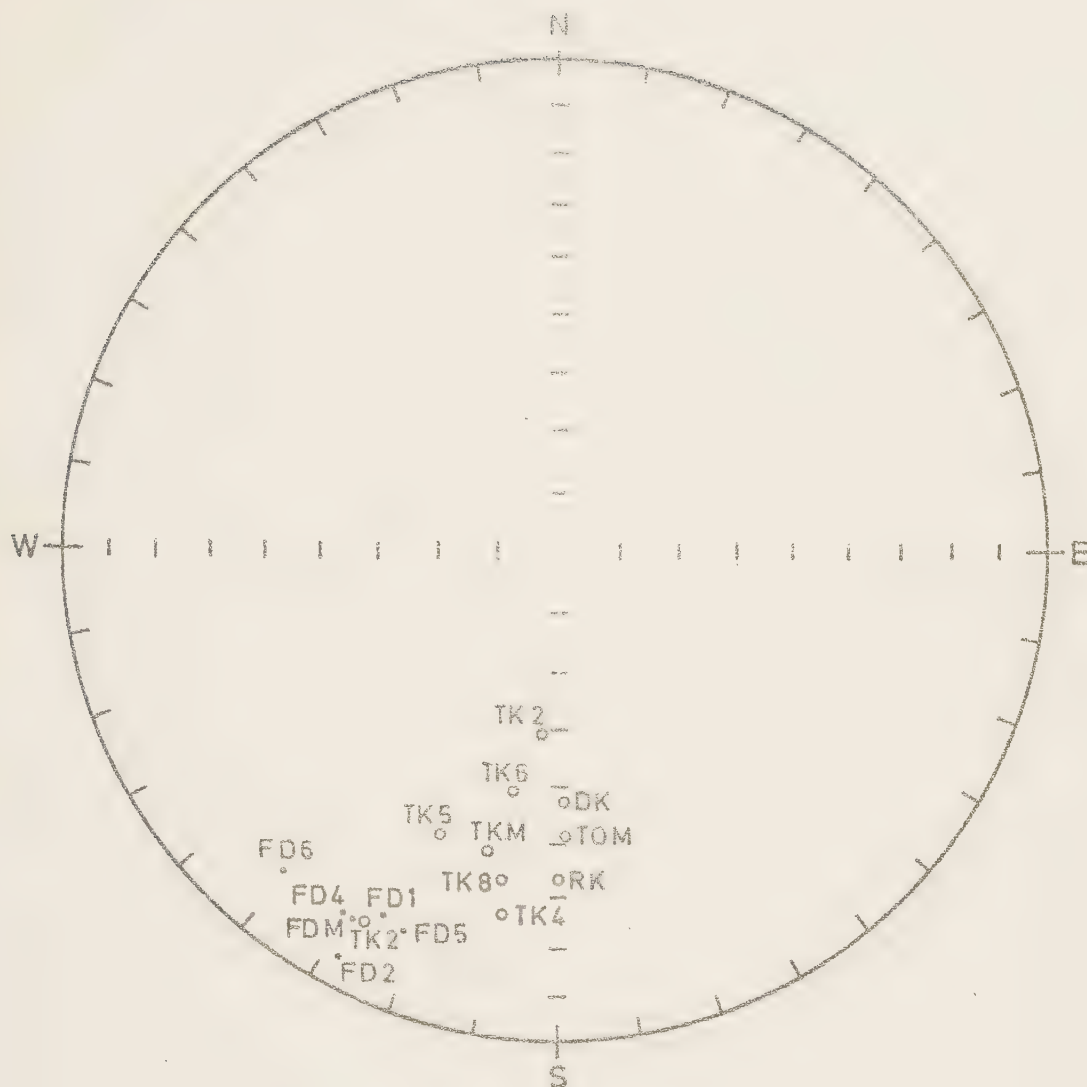


Fig. 30. Melaphyres, equal area stereographic projection of mean directions after demagnetization.
Dots = normal polarity, circles = reversed polarity.

RK = Rövarekulan

DK = Drakakull

FD = Frualid

TK = Torpa Klint

TOM = Mean direction, Tolånga type melaphyre

FDM = " " , Frualid melaphyre

TKM = " " , Torpa Klint basic dykes

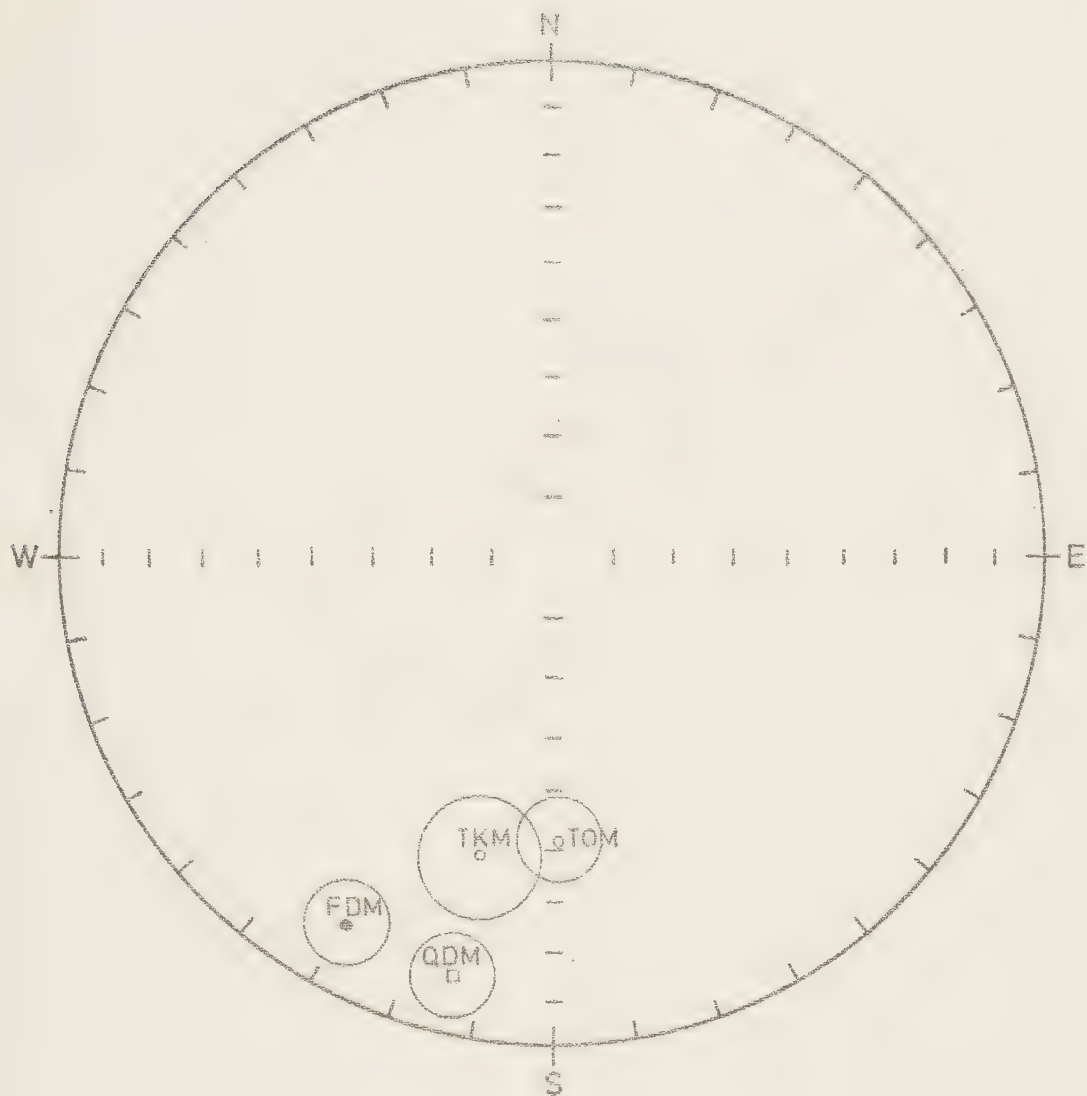


Fig. 31. Quartz dolerites and melaphyres, equal area stereographic projection, rock type mean directions after demagnetization. Dot = normal polarity, circles = reversed polarity. Big circles = 'circles of confidence.'

QDM = Quartz dolerite
 TOM = Tolånga type melaphyre
 FDM = Fruålid melaphyre
 TKM = Torpa Klint basic dykes

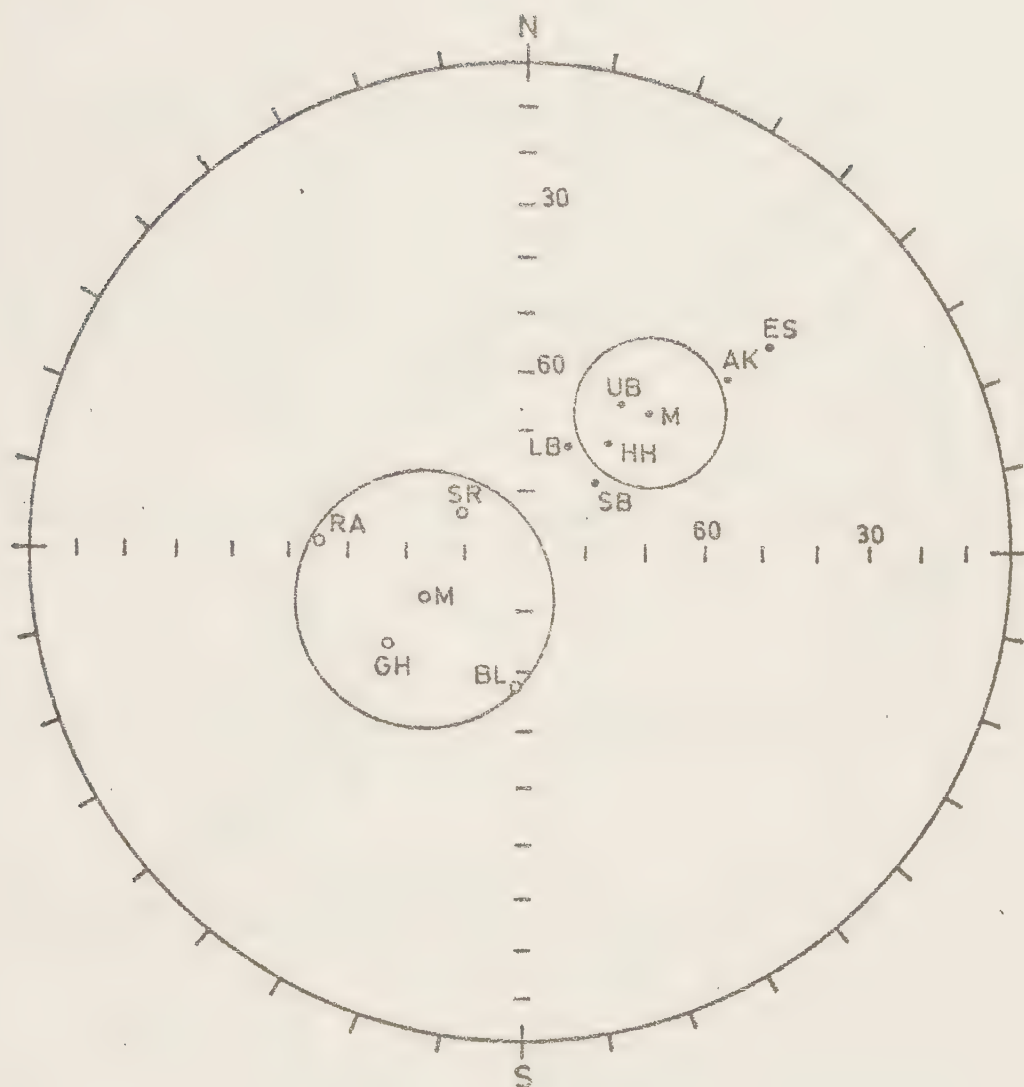


Fig. 32. Basalts, equal area stereographic projection of mean directions after demagnetization.

Dots = normal polarity, circles = reversed polarity.

Big circles = 'circles of confidence.'

ES = Espet

SB = Snababerg

LB = Lönneberg

AN = Anneklev

HH = Hästhallarna

UB = Ulfberg

GH = Göbnehall

SR = Säte-N. Rörum

BL = Bonarp-Ljungbyhed

RA = Rallate

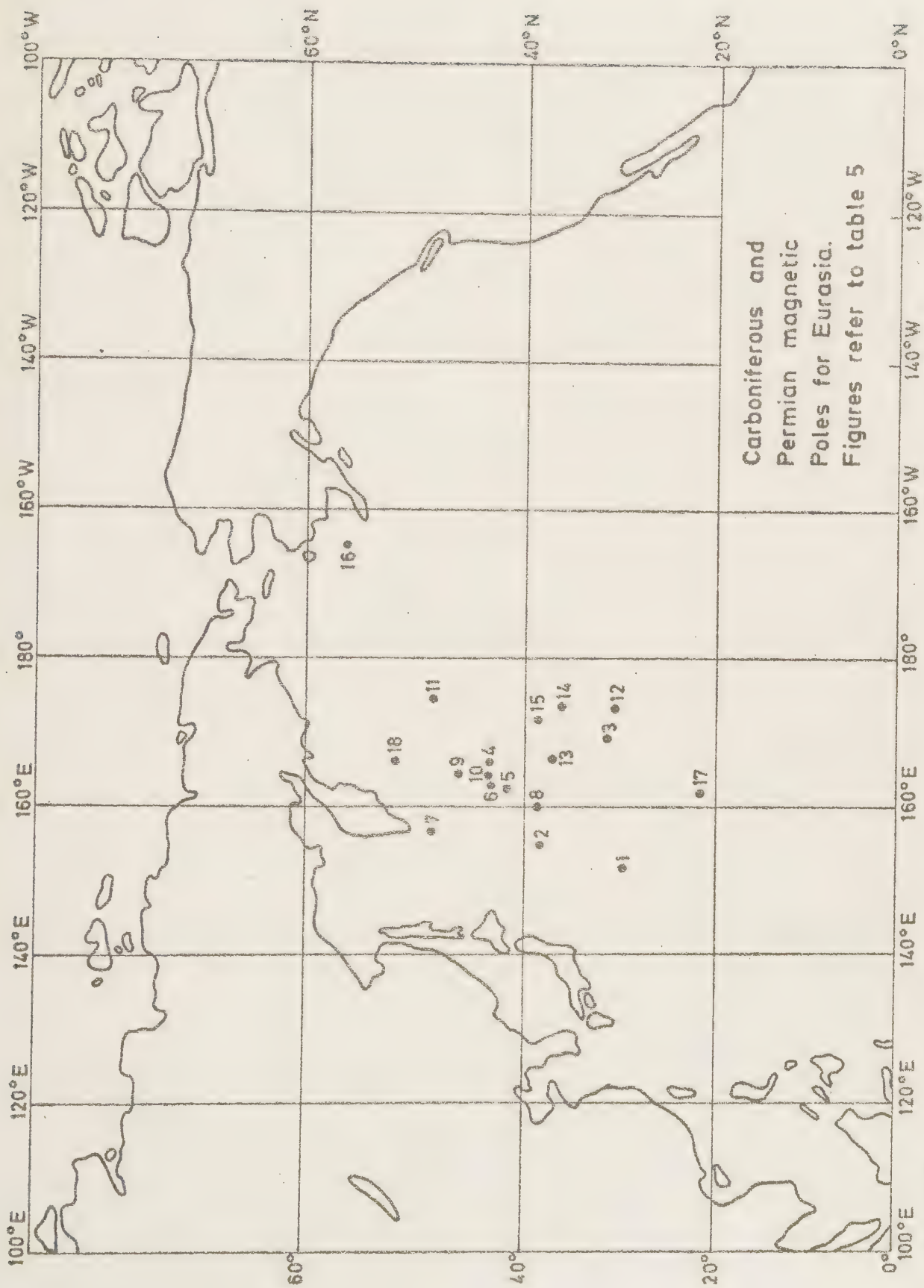


Fig. 33



Fig. 34

